Town and Gown: Visualising University Neighbourhoods as Places within the Urban Environment

The Example of Three Universities in Moscow

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Master thesis

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The Example of Three Universities in Moscow

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Statement of Authorship

Herewith I declare that I am the sole author of the submitted Master's thesis entitled:

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Moscow, October 2021 Milana Glebova

Abstract

This study attempts to improve the cartographic visualisation of crisp and fuzzy boundaries and internal structure of neighbourhoods as placial features on the example of three university neighbourhoods in Moscow. Human scientists and sociologists have been studying the geography of perception for a long time and have established a solid theoretical background, but the studies in that field lack proper cartographic visualisations. Staying on the crossroads between human geography, cartography and platial research, this study aims to develop suitable visualisation techniques to show how university neighbourhoods embed in the urban environment. To do so, a number of cartographic techniques to depict boundaries and internal structure of university neighbourhoods was generated. The survey was conducted in order to evaluate how these techniques deal with conveying information about the geography and sense of place of university neighbourhoods. The survey results indicated that most successful are the techniques which clearly show internal subdivision of a neighbourhood and allow to see the basemap under the symbology layer. The location of boundaries can be found out through a survey by gathering individual neighbourhood maps, while the core identification is needed additional verification. The implementation of these techniques for crisp and fuzzy boundaries depiction is discussed in the thesis.

Keywords: Fuzzy boundaries, neighbourhoods, places, visualisation, sense of place.

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1. Introduction

1.1. Context of research

In everyday life, people use a wide variety of geographical terms. However, most of them are not a part of a formal geographical vocabulary. City dwellers, for instance, often use identifiers such as “downtown” and, significantly less often, the names of official administrative districts. Even though unofficial names given by people are important for policy makers, businesses and real estate agencies, most of the time they are left unattended since geography of perception is hard to capture and use.

Researchers working in this field refer to informal regions as vernacular regions or neighbourhoods. Vernacular regions historically tend to be large portions of countries united by cultural and geographical connotations. Neighbourhoods are, in extreme cases, meant as small communities of people living in several houses at the end of cul-de-sac. But usually in urban studies the term “neighbourhood” is applied to areas within a city sharing some common stereotype and having a certain “popular” name. Both terms represent cognitive spatial objects of different scales.

A special case of a neighbourhood is a university campus and surrounding area associated with it within a city. It is an interesting spatial phenomenon since different campuses might have their own spatial relationships with a surrounding area – from isolation to interweaving – due to geographical, historical and institutional reasons. It is a challenging cartographic task to convey these complex relations in a clear way. Despite the noticeable differences, it is hard to portray these areas well on a map.

The aim of this thesis is to develop cartographic visualisations of boundaries and internal structure of three campuses in Moscow: Lomonosov Moscow State University (Vorobyovy Gory campus), Higher School of Economics (Myasnitskaya Street area) and Bauman Moscow State Technical University area.

1.2. Research Objectives

The general research objective of this study is to develop suitable visualisation techniques to show how university neighbourhoods embed in the urban environment.

This work is situated on the crossroads between neighbourhood studies in human geography and sociology, cartographic data visualisation and place theory. The idea is to build on the theoretical findings of geographers and sociologists and communicate them cartographically.

For clarity, we will split the general idea into two objectives:

RO1. Generating cartographic means to depict 1) boundaries and 2) internal structure of university neighbourhoods.

RO2. Empirically evaluating how these techniques deal with conveying information about the geography and sense of place of university neighbourhoods.

1.3. Research Questions and Methods

RQ1. What types of cartographic visualisation are suitable for depiction of neighbourhoods with both fuzzy and clear boundaries?

RQ1.1. Which types of boundaries exist for neighbourhoods, in particular university neighbourhoods?

RQ1.2. Which general techniques to convey fuzzy boundaries have been described in literature?

RQ1.3. Which of these or novel techniques to be developed can be applied to neighbourhood visualization?

RQ2. Which visualization techniques are able to represent the internal structure and connectivity between different parts of the neighbourhood in a suitable way?

RQ2.1 Which types of geographical features strongly contribute to the inner structure of a neighbourhood? (e.g., amenities, core and boundary, functional aspects, etc.)

RQ2.2 Which visualization techniques related to spatial patterns have been described in literature?

RQ2.3 Which visualization techniques that are traditionally not employed in the context of spatial patterns can be adapted?

RQ3. Do these techniques (chosen and/or developed in RQ1, RQ2) manage to clearly illustrate geography and sense of place of university neighbourhoods?

RQ3.1 How to identify the core, the boundary of a neighbourhood and different amenities within it?

RQ3.2 How well does the visualization convey an impression of the neighbourhood to people who are familiar with the area and people who are not? (here: first-year students and senior students)?

RQ3.3. Focusing on the example of campus neighbourhoods in Moscow, how do the techniques explored in RQ1 and RQ2 compare conceptually in the way they are able to convey information about boundaries, the neighbourhoods, and their structure? That is, what characteristics of boundaries, neighbourhoods, and structure are these techniques able to convey?

Digging into literature is the only possible way to observe existing techniques of neighbourhood representation (for RQ1.1-1.3 and RQ2.2-2.3). In order to broaden the range of observed methods, we can pay attention not only to thematically relevant sociological and cartographic studies but to sources loosely related to the topic, such as classic works of E. Tufte or data visualization projects. Both classical and adapted techniques will be tested on the post-processed survey materials by using ArcGIS tools and, optionally, vector graphics software.

Before answering the research questions per se, it will be necessary to find out the configuration of the university neighbourhoods in students' and residents' perception. The optimal way to do so is to conduct an online survey – that will provide the information for RQ2.1 and RQ3.1. Having these materials as a source, it is possible to overlay the resulting polygons, identify clear and fuzzy boundaries and (if possible) core areas for all three neighbourhoods by setting a threshold for each category. Analysing the answers can identify features building up the structure of these neighbourhoods and their valence.

The second questionnaire is supposed to evaluate the visualizations created on the previous steps. Comparing subjective impressions of the resulting techniques (how people like them) and answers to the questions (how easy it is to derive correct information from them) will make it possible to identify the most precise techniques to convey crisp and fuzzy neighbourhood boundaries (RQ3.2-3.3).

1.4. Contribution and Limitations

The study is aimed to contribute to the current neighbourhood research which is mostly lying on the cross section of human geography and social sciences: published works demonstrate solid theoretical background and interesting semantic findings, but they lack proper visualisations. This study is meant to apply cartographic methods to neighbourhood research and improve visual representation of university campuses as platial features within the complex urban environment. The research can be beneficial for human geographers and social scientists working in the field who want to better represent their own studies cartographically.

The study might be limited by a number of factors. From the technological point of view, the current GIS infrastructure is not absolutely suited for dealing with ambiguous geodata. Obtaining and processing fuzzy information with the tools developed for unambiguous information (lines and polygons with clear geometry) can lead to coarse results and this should be considered during the study.

Two social surveys are meant to play a prominent part in the research. Since the survey is going to be distributed across the author's personal and professional network, it may happen that the most of the participants will represent a coherent category of people with the same background and, possibly, spatial habits. On the one hand, it makes the potential results representative for this particular group, on the other – the whole population of the neighbourhood might not be properly represented.

In addition, the large part of the study is happening during the COVID-19 pandemic and affected by the restrictive measures related to it. Only online format is available for running surveys, which affects both the outcome of the process of information gathering.

1.5. Thesis Structure

The thesis is subdivided into six sections and has a sort of a recursive structure: first, the survey will be conducted to obtain the data needed for the study; then the data is going to be processed and visualised, and a second survey is planned to evaluate the visualisation techniques chosen on the previous step.

Introduction. The opening section starts with explaining a context of the study, then outlines the research objectives and lists the research questions set up in order to fulfil the objectives. The same section provides an intended contribution this study is meant to give to a scientific field and acknowledging the inevitable limitation which might narrow down the research.

Literature review. The literature review introduces the terminology which is going to be used in the thesis: explains the meaning of a neighbourhood in the context of the study and how it is linked to the platial theory. The focus is given to the boundaries visualisation and delineation. Also, the state of the current research in the field of fuzziness and uncertainty visualisation is observed in the chapter.

Prestudy. The prestudy chapter represents a nested research conducted in order to detect the boundaries, explore the geography of the studied neighbourhoods, and provide the study with the data which is going to be visualised and evaluated. The prestudy has its own methodology and the preliminary results. Also, the chapter makes the reader familiar with the study sites by giving a brief geographical and historical perspective.

Methodology. The methodology chapter provides a framework for the visualisation techniques design and evaluation. It sets the general principles of the techniques' generation and goes through all of them to reveal their affordances and anticipate how successfully the techniques will portray fuzziness. The evaluation survey design is also explained in the same chapter.

Results. The results chapter explores the output of the visualisation techniques creation by analysing the evaluation survey results. This analysis reveals how well the methodology of neighbourhood detection was defined and which of the visualisations works better to convey fuzzy boundaries and internal structures of neighbourhoods.

Conclusion. The chapter wraps up the research output by summarising its findings in relation to the research objectives formulated in the beginning of the study.

2. Literature review

The chapter describes theoretical concepts related to this research, existing neighbourhood delineation techniques and cartographic representations. The introduction explains the space and place dichotomy, the following subchapter articulates the nature of vernacular regions and neighbourhoods. The third part is focussed on the techniques visualising places and inevitable uncertainties related to them.

2.1 Space and place

The concept of "space and place" and how people perceive them is observed in the book by Y. Tuan who made an enormous impact on the development of the idea of place. He discusses how people interact with their home, neighbourhood, country. According to Tuan, "place" is linked to security and "space" to freedom; "space" means movement while "place" is a stop along the way. Tuan pointed out that the place does not have a certain scale or size providing the extreme examples of the favourite armchair by the fireplace and the whole Earth which both can be treated as places (Tuan, 1977). In his earlier work, "Topophilia: a Study of Environmental Perception, Attitudes, and Values" (Tuan, 1974), he examines more closely the phenomena of people's personal emotional attachments to places.

E. Relph contributed to the research with his study of phenomenology of place: in Place and Placelessness he focuses on everyday knowledge of places and reveals meanings and experiences typically hidden below the consciousness level (Seamon 2008). One of the most original contributions of his work is the elucidation of insideness and outsideness: "inside" a place a person feels safe and relaxed, while "outside" one feels exposed and alienated. Relph argues that the stronger the feeling of insideness, the deeper is the person's identity with the place (Relph, 1976).

There are other researchers working in the same field, such as T. Cresswell, who explained the concept of place in human geography and general terms related to it, relationship between space and place ("place is a space with a meaning"), in his book "Place: An Introduction" (Cresswell, 2004). To explain the concept of a meaningful location, he refers to J. Agnew who attributes them with three key aspects:

- Location (roughly, coordinates);
- Locale (affordances: features of a location which allow particular activities to take place there, e.g. "theatre", "mountains", etc.);
- Sense of place (personal perception of place based on associations, experience, etc) (Agnew, 1987).

The same set of characteristics is used in the study of S. Ross where he stands against reducing a place to a set of coordinates or a toponym – in other words, the location (Ross, 2015). The article describes the methodology of deriving both locations and locale from geotagged images and digitized texts on the example of "Mountains in the Alps" query. By doing so, it is possible to delineate "Alps" as a vernacular region by computing densities from toponym locations and "mountains" as locales. Both entities are fuzzy due to their nature, so Ross also argues that it requires a special database structure to store this kind of data in GIS and make it clear and accessible to non-expert users.

2.2. Mapping vernacular regions and neighbourhoods

2.2.1. Vernacular region

The current study operates with terms "neighbourhood" and "vernacular region"; there is a certain controversy between them. Vernacular regions had been a subject of scientific interest since the 1940s (Meigs, 1941) and reached their peak in the 1970s-1980s (Reed, 1976, Zelinsky, 1980, Shortridge 1985).

The work of the cultural geographer W. Zelinsky is considered a classic of human geography. He studied vernacular regions and defined them as "the product of the spatial perception of average people" (Zelinsky, 1980). He dealt with macro-scale geographical entities: he divided North America into fourteen large regions by analysing frequency of local place-names and enterprises, although he points out that numerous smaller regions nested within each other exist on lower scales. Resulting areas corresponded with already known cultural regions and showed how the strength of regional feeling is changing from place to place.

Nowadays cartographers are able to use the same methodology with automatically gathered data, just as D. Huffman did – not as a scientific research, but merely as a minor project, but, interestingly enough, the resulting map "The Midwest According to Business Names" corresponds to Zelinsky's findings:

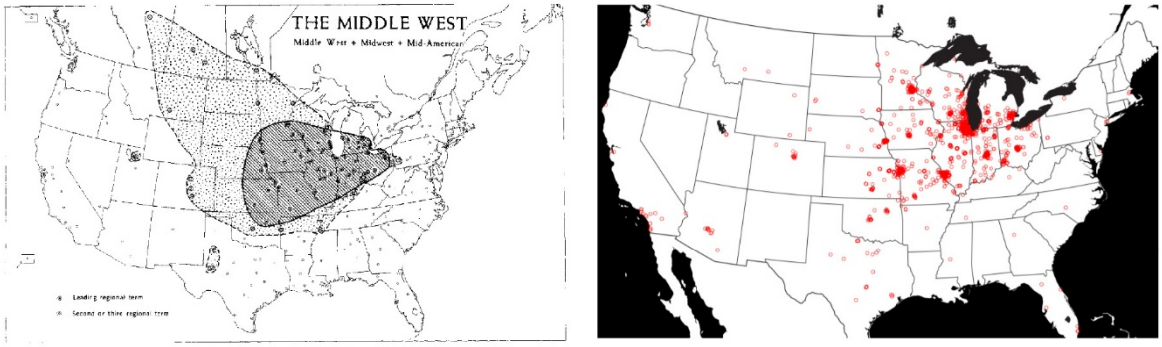


Fig. 2.1. The Midwest in the 1980s and the 2020s
(Zelinsky, 1980; somethingaboutmaps.com)

One of the earlier relevant works is dedicated to the Mormon culture region (Meinig, 1965). It never mentions the term "vernacular" as such, but the author broadly quotes the early

Zelinsky's publications while analysing historical expansion of the region and contractions between Mormons and Gentiles (non-Mormons) and follows his way of thinking. D. Meinig proposes a legitimate scheme of the culture region dividing it into three parts, by reducing the "power": core, domain, and sphere.

J. Mann has reproduced Zelinsky's method to study the Coast as a vernacular region in the US, taking advantage of GIS mapping software. In her study, she collected all the names of the enterprises having "coast(al)" in them and filtered them out so only local places' names are left in the dataset. In her study, she visualised distribution of points by using dot density maps, kernel density estimation and a cartogram to understand spatial pattern of people's identification of the Coast as a vernacular region, although representation of the boundaries was not one of the objectives. Also, the study contains a qualitative analysis of vernacular regional identity: what makes the coast a powerful symbol and how physical environment affects people's sense of place.

One of the ways to study informal regions is an indirect approach: by analysing local names, it is still possible to run surveys and gather mental maps. C. Didelon-Loiseau collected sketch maps from students in 18 countries to identify different types of world regions (Didelon-Loiseau et al. 2018). The survey has shown that some parts of the world are widely recognised as solid regions (e.g., Africa as a continent), while others are blurred (e.g., Middle East). Authors operate with terms of "hard" and "soft" mental regions to explain this tendency. "Hard" region has a high citation level and the respondents agree upon the location of its boundaries. "Soft" regions are named by a fewer number of participants and located either in the gaps between huge hard regions (like Russia) or as a part of them (for instance, South Africa), and frequently have fuzzy boundaries.

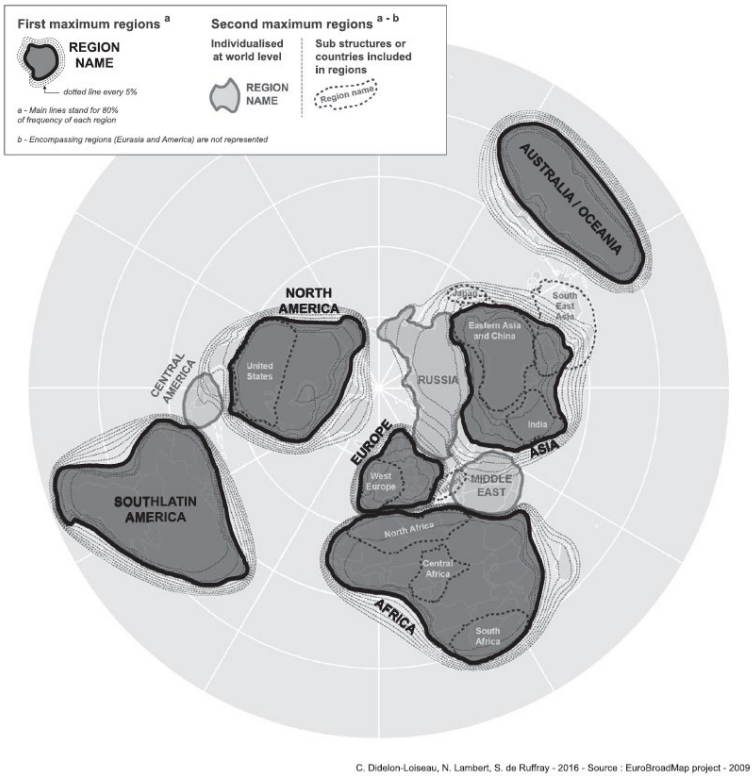


Fig. 2.2. Quantitative synthesis of world regions by Didelon-Loiseau et al. (2018)

J. J. Garcia Adeva focuses on a practical task of translating vernacular terms used by people to identify places into actual longitudinal locations (Garcia Adeva, 2008). The author experimented with a language independent statistical text mining approach. The idea is to paste information about a vernacular term that needs to be located, city, state and country to the software application interface; then, after computation the program returns geographic coordinates.

Analysis of vernacular regions of Moscow has been performed by S. Pavlyuk and K. Puzanov (Pavlyuk and Puzanov, 2018). The work is supported with strong geographical and sociological background, the authors identified many patterns in emergence of neighbourhoods in the city and their core parts, but the resulting maps do not provide relevant complexity of the outcome and could be enhanced.

2.2.2. Neighbourhoods

The term "neighbourhood" has numerous definitions and ways to identify it. For instance, S. Golab calls it "a physical or geographical entity with specific (subjective) boundaries" (Golab, 1982). By H. Hallman, the neighbourhood is "a limited territory within a larger urban area, where people inhabit dwellings and interact socially" (Hallman, 1984). C. Coulton defines it as "a geographically bounded grouping of households and institutions connected through structures and processes" (Coulton et al.,1999). All the definitions have in common that a neighbourhood implies a certain spatial extent and communications between residents (Galster, 2001).

T. Lee provides an intuitive set of factors influencing the individual neighbourhood: a number of local friends, a number of local organisations to which a person belongs to, and a person's tendency to visit local shops rather than shops in a city centre (Lee, 1963-1964). But it is important to remember that a neighbourhood is a collective entity, not individual, so, to form up a neighbourhood, mentioned factors would at least partly overlap on a certain territory for many people.

Because of ambiguity of the term "neighbourhood" and absence of unified set of characteristics to define it, it is common to ask residents themselves to name and/or outline their neighbourhood (e.g. Guest et al., 1983; Lee et al., 1997, etc.). Individual maps gathered during a survey can be later analysed in order to retrieve an interpolated boundary. C. Coulton, A. Poorthuis, C. Campbell observed different ways to identify boundaries – from traditionally collecting maps drawn by citizens to using social media data (Coulton, 1999, 2001, 2011; Poorthuis, 2017; Campbell et. al., 2009).

C. Coulton and S. Foster speak in favour of deliberately identified neighbourhoods in social study in comparison to official census blocks – the former are spatial entities defined not only geographically, they also consider communications between citizens and their shared experiences, so-called community effect. But, since a neighbourhood is a product of people's collective perception, it is difficult to identify its borders and visually represent them. S. Foster tests the method of "tertiary communities" identification: the hypothesis is that social interaction is facilitated in the areas intersected by residential (tertiary) streets while non-walkable highways, waterways and parks play a role of natural barriers between these "t-communities" (Grannis, 1998, cited in Foster, 2011). The method has its limitations though; it is also worth noticing that it was only tested on American cities.

B. Entwisle provides an overview of existing research on neighbourhoods and effects they have on residents' health (Entwisle, 2007). The general critique is that most of the articles consider people as just passive recipients who are exposed to neighbourhood effects such as certain standard of living, crime situation, traffic noise, etc. and are influenced by them. Also, existing work is based on statistics gathered by official census blocks and does not necessarily represent neighbourhoods as spatial and social entities. The paper recommends demographers as its target audience to consider people as active actors within the environment and to consider changing local context to explain the connection between neighbourhoods and health.

2.2.3. University campuses

The topic of university campuses and their interrelations with a city surrounding them is discussed in the works of M, Ehlenz, M. Munro and M. Livingston. They observe how university areas evolve from isolated campuses and transformed areas around them, boosting urban revitalisation. They found that, in a territorial sense, town and gown boundaries are becoming more blurred (Ehlenz, 2018; Munro and Livingston, 2012). The town and gown dichotomy itself is described theoretically (e.g., Brockliss, 2000). L. Brockliss provides an overview of this phenomena in Europe across the centuries and debates by which extent current cooperation between town and gown are defined by their shared history.

2.3. Cartographic techniques to convey places

There is ongoing research focussed on the ability of maps to convey places. F.-B. Mocnik and D. Fairbairn discuss how well maps communicate stories in comparison to a written text. Generally, text is more capable of conveying an atmosphere of a place; the paper examines how changing of map style can improve the depiction of atmosphere of an area (Mocnik and Fairbairn, 2018). J. Gardener considers map as a tool to evoke emotional connection to place by using various artistic expressions (Gardener et. al., 2019). D. Powell explores a cartographical method which would connect relationships between place, lived experience, and community on the example of El Chorrillo neighbourhood in Panama City, Panama (Powell, 2010). L. Harvey develops a visual representation technique for place ballets on the example of London parks, focussing on conveying atmosphere and tension related to those places (Harvey, 2020).

A. Poplin experiments with mapping places and emotions, focussing on places where people feel comfortable and relaxed (Poplin, 2017). Places in this study are simplified to point locations, although the author articulates affiliation of both places and emotions to fuzzy concepts: places, where people "recharge", do not have a crisp boundary, as well as emotions associated to them are difficult to clearly define.

Other works explore the phenomenon of collective experience and shared sense of place. J. Gardener with colleagues studies portraying memory, experience and reflection through maps and narratives on the example of Edenborough Gardens in Melbourne, Australia. They aimed to explore maps' ability to enhance understanding and perception of places (Gardener et al., 2019).

A number of articles related to the topic indicate its relevance, but by no means all the questions are already answered and cartographic depiction of placial aspects remains a relevant topic of scientific research.

2.3.1. Visual variables

Visual variables can be described as a result of breaking down visualisation techniques into graphic dimensions. French cartographer J. Bertin was the first scholar who described them in his book "Semiologie Graphique" released in 1967, which was translated into English in 1983 as "Semiology of Graphics". According to J. Bertin, visual variables are basic building blocks that form up any visualisation, in particular, a map (Bertin, 1983).

The visual variables enlisted by J. Bertin are location, size, shape, orientation, colour hue, colour value and texture. The original set was extended by J. Morrison, who identified colour saturation and arrangement as additional variables (Morrison, 1974), and A. MacEachren, who added crispness, resolution and transparency to the list (MacEachren, 1995). Visual variables are perceived on a subconscious level rather than understood consciously and by manipulating them cartographers can influence the effect map has on a reader (Roth, 2016).

2.3.2. Visualising uncertainty

It became a common knowledge that uncertainty is not just an error to be eliminated but an inherent characteristic of geographical data (Roth, 2009). According to A. Pang, there are three stages at which acquiring uncertainty is possible: data acquisition, data refining, and visualisation (Pang, 2001). According to P. Fisher, uncertainty can be of different nature and applies for both well-defined and poorly defined objects. Error represents a difference between a true value and a given value within a well-defined object. For poorly defined objects, vagueness occurs as a result of loosely defined terms or because of the fuzzy nature of an object itself; ambiguity stands for confusion between different concepts having the same name (Zhang, 2008).

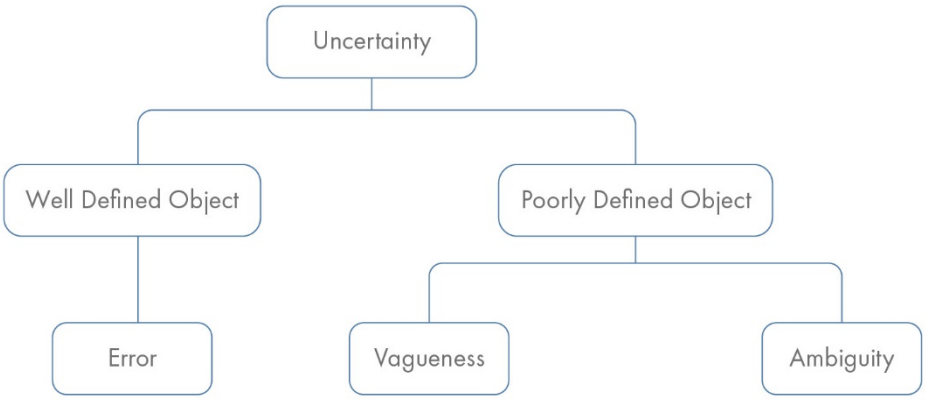


Fig. 2.3. Types of uncertainty (adapted from Fisher et al., 2006)

A. MacEachren extents the typology of geospatial information uncertainty initially formulated by M. Thomson (Thomson, 2005): accuracy/error, precision, completeness, consistency, lineage, currency, credibility, subjectivity, interrelatedness. Each of these types is linked to the space, time and attribute components of data. The first task the researcher

solves is deciding which part of a symbol should be responsible for the data depiction itself and which part shows data uncertainty. It is common to start with visual variables: their combinations result in different techniques conveying uncertainty, but the research of how successful these techniques are is still limited.

C. Kinkeldey, A. MacEachren and J. Schiewe have provided an exhaustive review of all the user studies conducted to evaluate various uncertainty geospatial visualisation techniques published between 1992 and 2014. To describe them, the authors proposed a set of three dichotomies:

- coincident/adjacent: data and uncertainty shown in the same view/in separate views;
- intrinsic/extrinsic: uncertainty is integrated into existing symbology, which is another form of multivariate mapping;
- static/dynamic: classic map/interactive map or animation.

The researchers found 44 studies described in 34 publications. The study revealed that intrinsic techniques largely prevail over extrinsic and mostly include shifting colour hue, value or saturation, and applying transparency masks, blurring or changing resolution (Kinkeldey et al., 2014). Regarding coincident/adjacent views the results are more ambiguous: on the one hand, it is generally easier to retrieve information from adjacent maps and obviously requires fewer eye movements, on the other – in case of complex maps deployment of coincident views is justified in order to avoid clutter. Also, they concluded that animated maps have their potential in conveying uncertainty data, but there is little evidence how successful they are.

In the paper "Visualizing Geospatial Information Uncertainty: What We Know and What We Need to Know", A. MacEachren provides a comprehensive review of existing research on the topic and illustrates how the concept of uncertainty visualisation has been evolving. The authors admit that the topic had been given certain attention, but across several disciplines there is still no general understanding which parameters work well for depicting uncertainty (MacEachren et al., 2005).

In the following research A. MacEachren explored the intuitiveness of visual variables in comparison to iconic sign vehicles, and compared performance to the most intuitive abstract and iconic symbols by running two linked experiments (MacEachren et al., 2012). They only focused on visualising uncertainty of discrete items, therefore only point symbols were tested. The researchers found out that it varies greatly how well abstract symbols based upon single visual variables deal with representing uncertainty. Fuzziness and location proved themselves to be the most intuitive variables, value and arrangement worked well, and size and transparency are also acceptable. The study disproved the opinion, often mentioned in the publications, that saturation is intuitively associated with uncertainty, which turned out not to be true. Another outcome of the study is that while iconic representations are generally more intuitive, abstract symbols are quicker perceived by the map readers.

One of the user studies on uncertainty perception is done by J. Sanyal, who tested it on four common uncertainty visualization techniques in 1D and 2D data, such as error bars, scaled size of glyphs, colour-mapping on glyphs, and colour-mapping of uncertainty on the data

surface. The participants had to solve a number of tasks: identify the most and the least certain data or count uncertain features. According to the results, changing the glyphs size and colour-mapping of the surface worked well, but error bars performed consistently poorly (Sanyal et al., 2009).

Some researchers go further and analyse how uncertainty visualisation affects decision making: for instance, R. Roth compared how experienced GIS specialists and novices deal with geographic risk assessment under uncertain conditions (Roth, 2009). R. Roth examined the domain of floodplain mapping since it is a particularly responsible area where either cartographer's or user's mistake can lead to severe real-world consequences. At the same time, floodplain maps are widely used by non-specialists and are known to the general public. The experiment proved that, in general, domain specialists are better equipped to understand implemented uncertainty and consider it while making risk assessments. At the same time, prior research (Evans, 1997 cited in Roth, 2009) shows that in case of simple tasks of merely retrieving information and not making judgements from maps displaying uncertainty the level of expertise does not make a dramatic difference. So, all levels of expertise should not be treated equally and it is important to know the user while designing uncertainty representations.

2.3.3. Exploring fuzziness

Fuzziness is a concept tightly connected to uncertainty, it can be used as a substitute for vagueness (Zhang, 2008). "Place", being more ambiguous than "space", often has fuzzy boundaries. It is a crucial concept for this study since city neighbourhoods as places are rather typical examples of fuzzy objects. The same can be applied to vernacular regions in general (Didelon-Loiseau et al. 2018).

A research on manipulating visual variables for fuzzy boundaries depiction has been underway for a long time. For instance, usage of colour variables – in particular, hue, saturation and value – to visualise a town centre which is a typical fuzzy concept (Jiang, 1998).

Although, current research focuses not only on the ways how to visualise fuzzy objects, but how to collect information about them as well. A. Evans and T. Waters observe urban vernacular areas in the light of the ways of capturing them and using standard GIS datasets. In their study, authors provided participants with a dot-plane spray tool familiar from default graphic packages and invited them to mark high-crime areas in Leeds, UK (Evans, 2007). Using spray can allows to control varying intensity of crime risk to a participant. Resulting point cloud can be recalculated into a raster surface by using kernel density estimation. Although this tool gives more flexibility to the participants – they can draw both crisp and vague boundaries – it is not available in standard mapping services. Other scholars (Huck et al., 2014) intend to overcome this obstacle by providing a "Spraycan" platform to gather information about vague regions and store it within a "multi-point-and-attribute" data structure. According to the authors, it better represents place-based feelings in comparison to default space-related GIS features. There is a recognized need to establish place-based GIS in order to deal with this issue (Goodchild, 2011).

3. Prestudy

The following chapter is dedicated to the areas chosen as study sites and meant to explain why they are relevant to the current research. It is followed by the first survey outline and the discussion of its results, the most important of which is the information on the neighbourhoods' extent and places which contribute to their inner structure.

3.1. The Study Sites

The term "campus", meaning college grounds, was first used in that sense in 1774 in relation to Princeton. In Latin, "campus" means a "flat land, field". The etymology of this word points to the spatial extent of the territories occupied by the first universities. To avoid confusion, in this study I use the word "campus" when referring to official grounds, areas where university facilities are located; in relation to perceptual areas derived from the survey or drawn individually by the respondents, I use the term "neighbourhood" and "university neighbourhood" in particular.

Although university campuses as urban facilities vary strongly across different countries, one might roughly classify them into three types: country university campuses (out-of-town), local centralised city campuses and distributed city campuses.

Three Moscow university campuses were chosen as study sites: Lomonosov Moscow State University (hereinafter MSU), Higher School of Economics (hereinafter HSE), and Bauman Technical University (hereinafter TU Bauman). Since all of them own several separate campuses within the city, I chose to focus on the sites described below.

3.1.1. The Moscow State University campus

The MSU's Vorobyevy Gory ("Sparrow Hills") campus was built in 1950-s, when its territory was considered as the outskirts of the city. Even though an extensive urban sprawl made it a semi-periphery regarded to be rather close to the centre, the campus still remains quite isolated. The high fence around the old historical part is not the only reason for that; the campus itself was designed as a self-sufficient university district with its own small stores, hospitals, gyms, and student residences as well as lecture halls. Theoretically one can even graduate from the university and never leave the campus during the whole study period (which is a rather questionable idea from a psychological health point of view). Also, it is apparently too far for people from neighbouring residential blocks to go for a walk in the parks on campus – it is separated from them by other green areas, highways, a wasteland – so people from the "outside" rarely visit the students' area. Also, they might just not feel comfortable in the student area. Vorobyovy Gory campus is sometimes called "a State within a State" because it is believed to be living according to its own spoken and unspoken laws.

Among Russian campuses, it most closely resembles the classic Western campuses: with not Gothic but Empire style spires and gates, inner yards and lawns.

3.1.2. The Higher School of Economics campus

Both configuration and historical background of the HSE campus are absolutely different. From 2011 to 2013, the university reorganised the structure of its premises, building up a so-called distributed campus. Various buildings are supposed to be located within several clusters in central Moscow linked by public transport. The practical reason behind launching this program was an obsolescence of the infrastructure: the existing lecture halls were too distant from each other and were not able to host the increasing number of students. Another motivation for this renovation is to boost economic growth and social life in the historical part of the city: it has not fully exploited its potential; and many streets and courtyards are used as service spaces and are closed to both tourists and locals. The district, according to the programme, should be transformed into a historical environment with "university spirit" and active student life. The closest counterparts to these practices are Harvard, Sorbonne (Latin Quarter), and New York University in Greenwich Village. The core of such a structure is planned to be formed between Myasnitskaya Street, Solyanka Street and Pokrovsky and Chistoprudny Boulevards.

3.1.3. The Bauman Technical University campus

The TU Bauman campus is located near Baumanskaya underground station, its key buildings are facing Gospitalny pereulok and Lefortovskaya embankment. At least from an outsider's perspective, it has no pronounced impact on the surrounding area – apart from the cheerful crowds of students heading from and to the underground station twice a day, the area shows no signs of being a university quarter. Apparently, this campus, although put into an urban space, does not transform it. This is indirectly confirmed by the new campus development programme, which, in addition to the construction of new buildings, intends to integrate the campus into surrounding urban areas and make it open to local citizens.

Thus, we have three urban campuses with different spatial structures and varying relationships of places within them. In addition and beyond the outlined rationale to choose these particular places as a subject of the study, there was also a strictly personal motivation: having spent more than five years on the MSU Vorobyovy Gory campus and feeling a deep attachment to the place as well as its "otherness" from the surrounding city, the author of this thesis was interested to find out how other residents delineate and perceive the area, whether or not they share the same topophilia. The knowledge about this place helps enormously to design and conduct the current research.

3.2. Methodology

Although most people keep fairly detailed information about the places where they live or work in their memory, their image of a place is almost never complete or absolutely accurate. It may, for instance, not include certain parts of an area if the person never visits these parts. On the other hand, objects that are significant to the person may be perceived at a larger scale. The mental image also often smooths complex paths, making them straight, and

reduces entire groups of objects to abstract areas for easier comprehension and navigation. Because our perception of territory differs so much from its actual physical characteristics, it is important to study the images of territory held by different city dwellers. One particularly suitable way to do so is to conduct an online survey. Even though people always use vernacular toponyms in everyday life, it is hard to explain what they are supposed to do when asked about neighbourhood boundaries and an online survey is a convenient tool in this case since respondents have time to think what territory they consider their neighbourhood.

The aim is to receive 50 responses from each of the universities: 40 from students and 10 from people who just live or work in the area; these numbers seem sufficient enough to provide a realistic insight. The survey is not supposed to take longer than 15 minutes. All the responses are anonymous, therefore personal data privacy has not been violated.

The central part of both the major research and the pre-study is an online survey. The pre-study survey is an advance step created in order to gather information about the perceptual neighbourhoods' shape as well as possible insights from the locals. Needless to say, there are other tools for identifying "people's" neighbourhoods indirectly, such as using volunteered geographic information, for instance, by obtaining neighbourhoods' nicknames from social media posts and plotting them on a map. Although, this method is not yet fully developed and is the subject of a separate study.

The survey is largely designed to receive descriptive information about the neighbourhoods apart from identifying their shape, and the respondents' background and habits relevant to the "sense of place" research. Adapting Creswell's list of three key aspects of place – locations, locale, and sense of place (Cresswell, 2004) – the questions will directly or indirectly touch each of these categories. Following the introduction part explaining the purpose of the survey, the meaning of the neighbourhood in its context, and the data protection statement, participants are asked about their university affiliation and the length of time they have known the area.

Table 3.1. Srvey sections. The screenshots with all the survey pages are provided in the Appendix 1.

Introduction
University affiliation, occupation, length of acquaintance
The boundaries of a neighbourhood
Drawing the borders of a neighbourhood on a web map
The centre of a neighbourhood
Drawing the core part of a neighbourhood on a web map
The "skeleton" on the neighbourhood
Drawing the most frequently walked streets on a web map
Additional information
Transportation means of getting to the university; places visited most often for the purpose of studying or leisure; most comfortable places on the campus and nicknames for the places within the campus.

The main section of the survey contains three questions where the participants are supposed to draw the boundaries of their neighbourhood, to locate its centre and to mark the streets they walk more often. While the first two questions are crucial for identifying the research areas, the third question leaves a possibility for a deeper analysis of internal spatial structure. The participants are provided with a link to the customised geohub with a function of public editing where they could draw polygons and lines stored as answers to respective questions. The web map interface is not absolutely intuitive so the questions where one was supposed to draw an area or a route on a map are accompanied by “how-to” GIFs.

The geospatial data was collected through the Geosemantika platform: a free (for one project) geohub which allows the creation and maintenance of web maps. One of the Mapbox basemap styles was customised to serve the needs of the survey: distracting features were eliminated while the focus was given to landmarks and points of interest to make the navigation and places recognition easier. Also, the subway stations and their exits as major orientation landmarks were added with their brand design.

All the data can be downloaded as a GeoJSON file and opened in any GIS software. To allow join of the collected polygon and line features to the answers table, they both contained a date-time field.

Fig. 3.1. The basemap in the Geosemantika interface

The third pile of questions is aimed to collect qualitative information about places, such as the most visited shops and cafes, areas where the respondents feel the most comfortable in, popular nicknames for places, etc. In this section multiple choice questions and short answer questions are presented, allowing the participants to elaborate on their attachments to places. The answers from this section can be also used to indirectly verify the core parts locations.

The answer blocks are created in a way so they do not restrict participants only to given options and encourage them to give context or provide comments to their answers (if they want to). The questions were meant to make the participants reflect on their “neighbourhood identity” rather than just provide the raw data for the research. Translated answers are presented in the Appendix 2.

The link to the survey was posted on social media platforms including Instagram, Facebook and VKontakte and shared among the author's private network. Since the survey was launched on May 24th 2001, it was completed 85 times over the course of two weeks. To make it easier for participants, the survey was designed and distributed in Russian.

3.3. Results

The following subchapter provides an overview of the results obtained from the survey questions.

3.3.1. Population

In total, the number of collected survey results is 85. They are unevenly distributed across the universities:

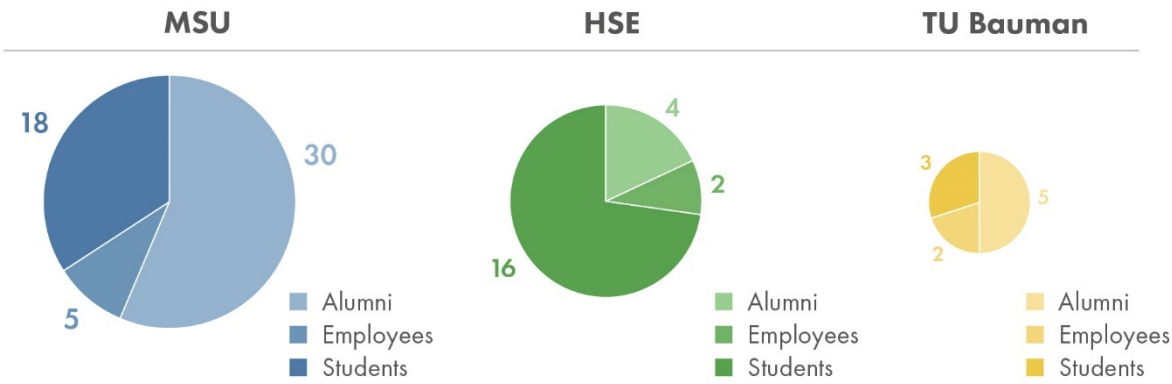


Fig. 3.2. Respondents and their affiliation

Most respondents – 62% (53 people) – are students, alumni and teachers of MSU; 26% (22 people) of the respondents are from HSE and 12% (10 people) came from TU Bauman. The latter number is somewhat disappointing, so little data can hardly be used for a meaningful analysis, but we should by no means ignore it. Thus, we will involuntarily focus on two campuses, MSU and HSE, turning our attention to the third campus when the data allows us to make comparisons.

More than a half of MSU respondents are graduates, and together with staff members their share reaches 2/3. At the same time, almost 75% of those surveyed at HSE are students. There is a possibility that the answers of the MSU and TU Bauman campus residents may be more conservative; this is also illustrated by the graph showing for how long the respondents are familiar with their campuses:

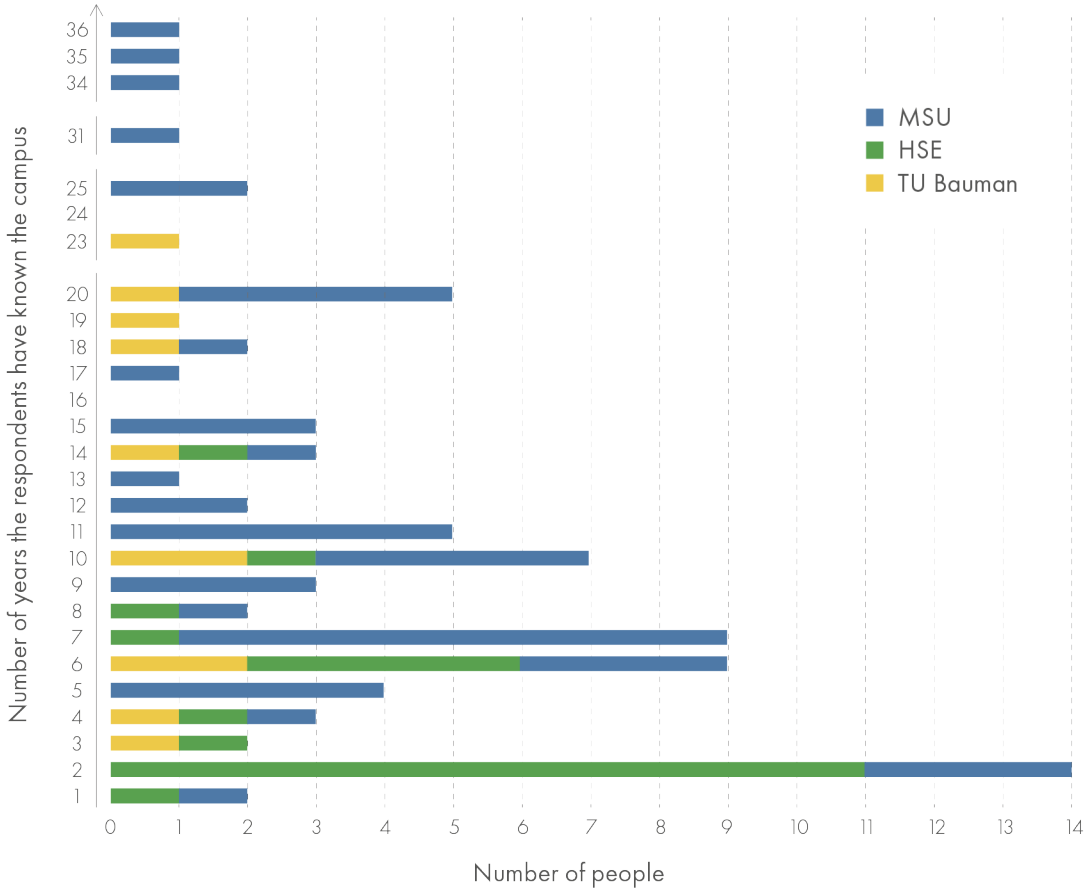


Fig. 3.3. Distribution of the respondents by the length of their acquaintance with the university area

The mean "age" of acquaintance of the respondents with HSE is 4 years, while for MSU this number reaches dramatically different 12; for TU Bauman the mean age is almost 14. This uneven distribution might affect the outcome of the study and needs to be considered in the analysis.

3.3.2. Configuration of the neighbourhoods and their centres

This subsection describes geospatial information about the university neighbourhoods gathered through the survey. The extent of the areas outlined as individual neighbourhoods varies greatly:

Fig. 3.4. The outlines of the neighbourhoods drawn by the respondents

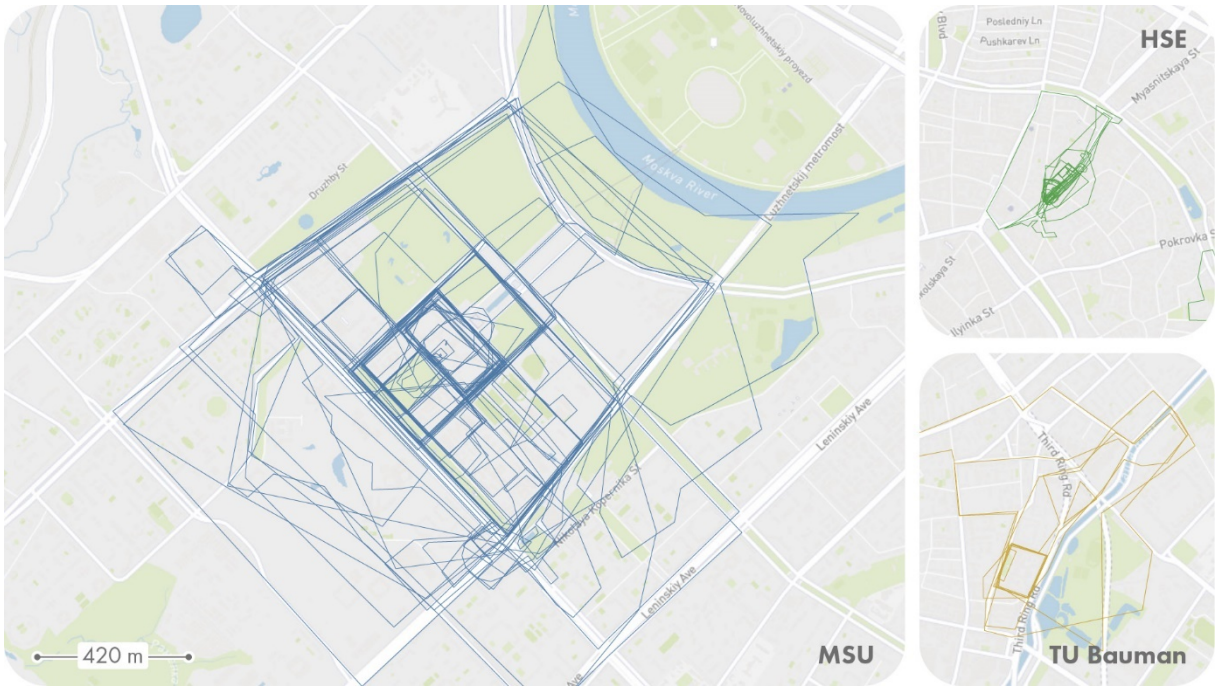


Fig. 3.5. The outlines of the neighbourhoods' centres drawn by the respondents

Depending on how the respondents perceive their neighbourhood (and, possibly, how clearly the task was presented to them), they outlined the areas considered their own. For instance, the area occupied by individual MSU neighbourhoods varies from 0.5 km^2 to 6 km^2; for the HSE neighbourhood the spread is from 6500 m^2 up to 1.5 km^2; for the TU Bauman – from 1600 m^2 up to 1.2 km^2.

One of the ways of delineating informal regions is to divide the study area into cells and calculate for each cell a percentage of the respondents who claimed it a certain region. To do so, an auxiliary polygonal layer of square cells was created and each cell was assigned with the calculated number of intersecting polygons – identically to the raster calculator operations. By initially choosing a small cell size, it is possible to construct a smooth surface that clearly displays the distribution.

Since the data coverage is uneven, it makes sense to show weighted values – that is, the percentage of survey participants from each neighbourhood who designated a given cell as part of their university district. This simple method gives some clarity to the data and one can already recognise the varying intensity pattern:

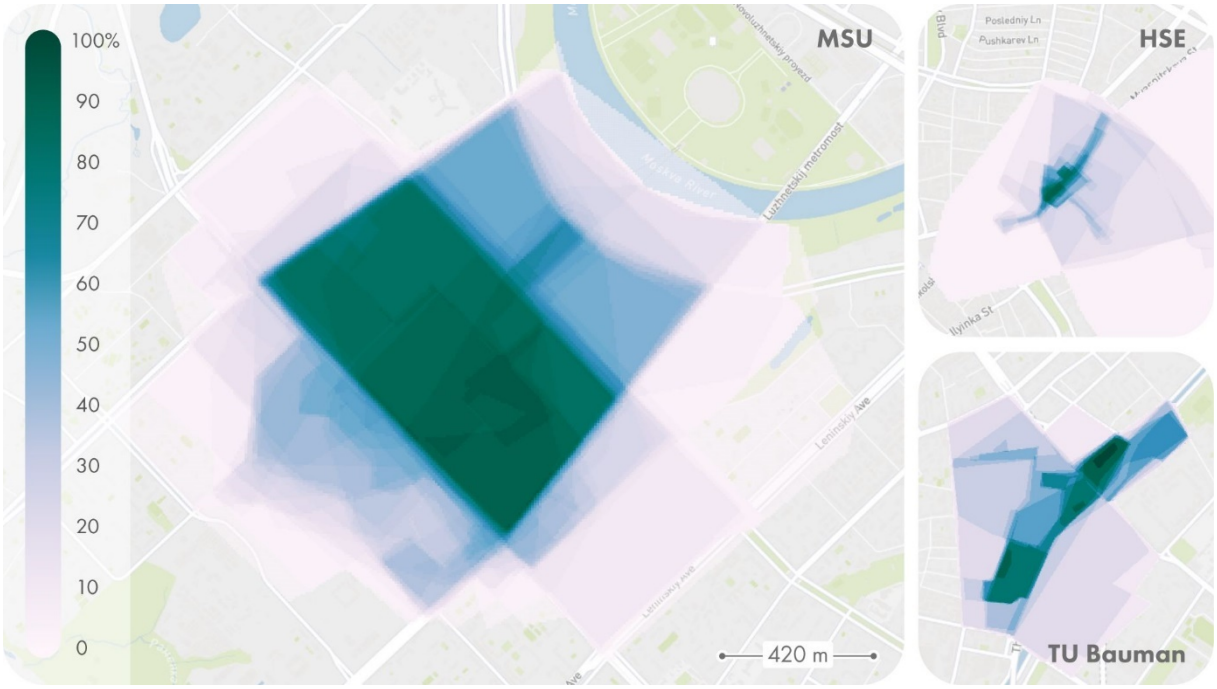


Fig. 3.6. University neighbourhoods as marked by a corresponding percentage of the respondents

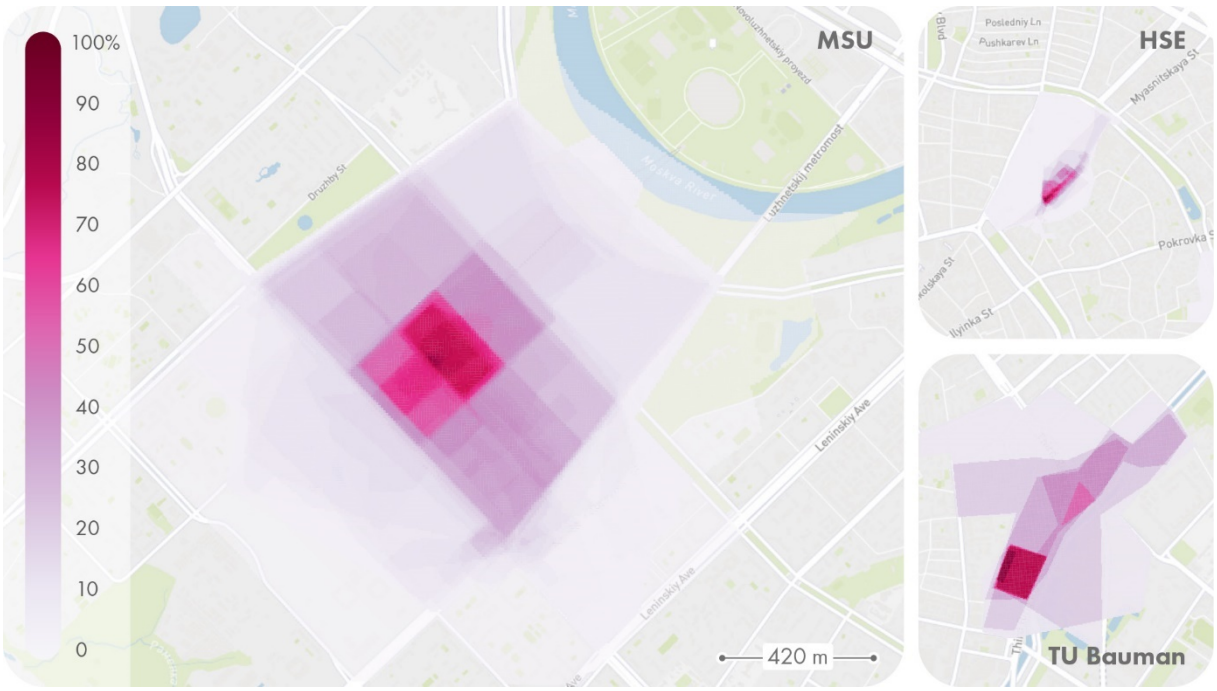


Fig. 3.7. University neighbourhoods' centres as marked by a corresponding percentage of the respondents

In the complicated case of fuzzy boundaries, it is not only unclear how to visualise them (RO1), but how to identify them in the first place. The current study adapts the terminology from (Meinig 1965) to allocate three hierarchical levels of the neighbourhood: core, domain and sphere. The paper does not provide the methodology of retrieving these parts, so it was arbitrarily decided to classify them as follows:

- core: the area marked as the core by 50% (or more) of the respondents;
- domain: the area marked as the neighbourhood by 50% (or more) of the respondents;
- sphere: the area marked as the neighbourhood by 25-49% of the respondents.

Fig. 3.8. Scheme of the neighbourhood delineation

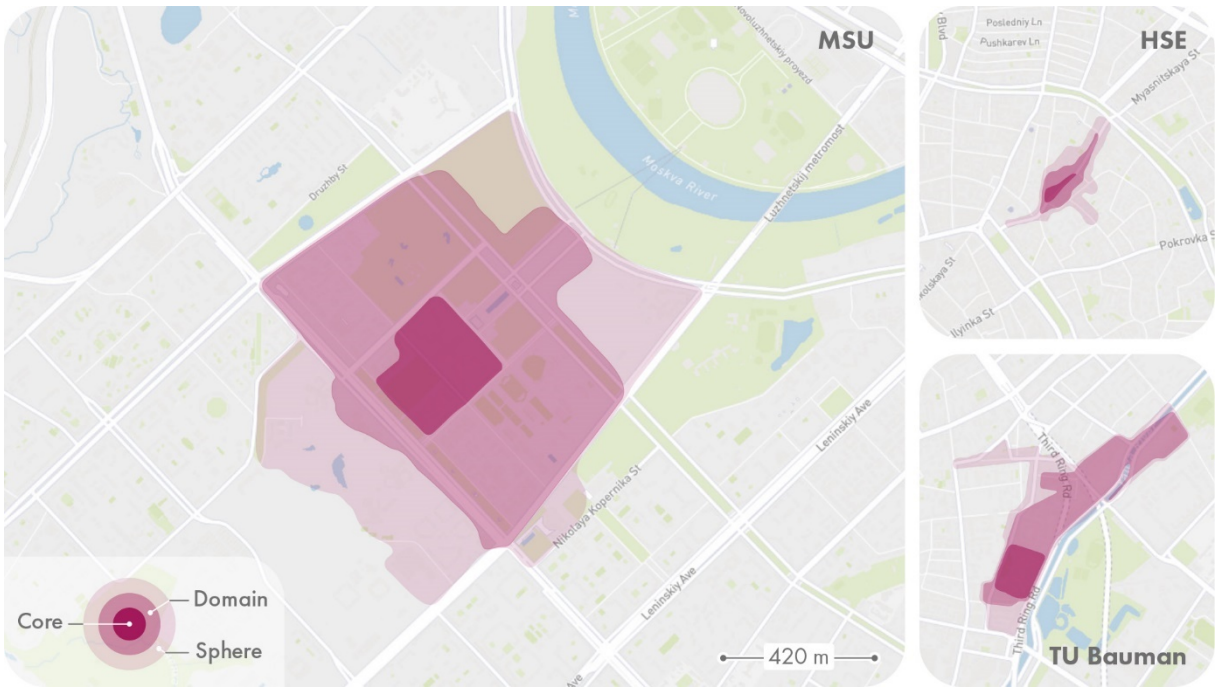


Fig. 3.9. Core, domain and sphere of the neighbourhoods

3.3.3. Places within the neighbourhoods

The third part of the survey contained open and multiple-choice questions designed to get insights possibly explaining a local sense of place. One of the questions – transportation means of arriving at the university – turned out to be irrelevant while others do provide some context to the current neighbourhood study.

The questions regarding places where the respondents spend their free time studying (or preparing for classes, in case of employees) and meeting with peers were asked in order to find out where all the activity is located within the neighbourhood and if the neighbourhood extends beyond the official campus borders. These places are not included into the visualisations per se, but the areas where they are concentrated have helped to verify core and domain parts of the neighbourhoods and how far they extend.

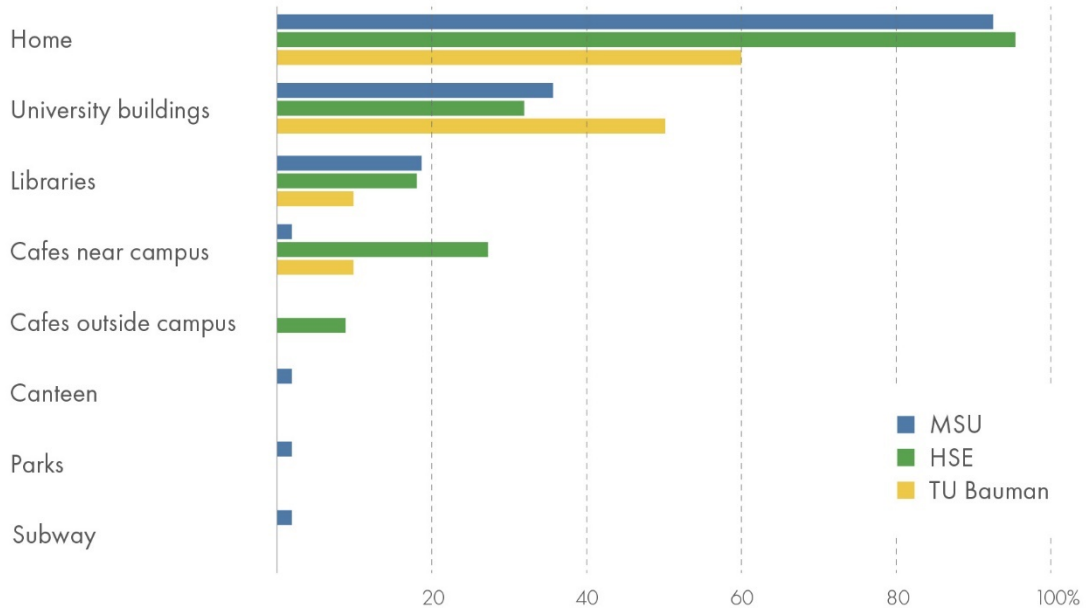


Fig. 3.10. Places to study (showing the percentage of the respondents from each group)

According to the results, most of the participants predictably study at home or at university. The interesting outlier here is the high number of cafes inside and outside the campus indicated by the HSE students (see Fig. 3.10). Indeed, the respondents include cafes they often visit in their neighbourhoods, for instance: *"Starbucks was a second home for those who studied on Myasnitskaya, sometimes they would even close the place later because the students were finishing their assignments there. The deadline was always at 23:59 and many projects were uploaded to the system on the porch of the Starbucks after closing time".* Dissimilarity with the two other campuses makes it an interesting feature of the HSE – the area around the official grounds is also adjoined to the neighbourhood.

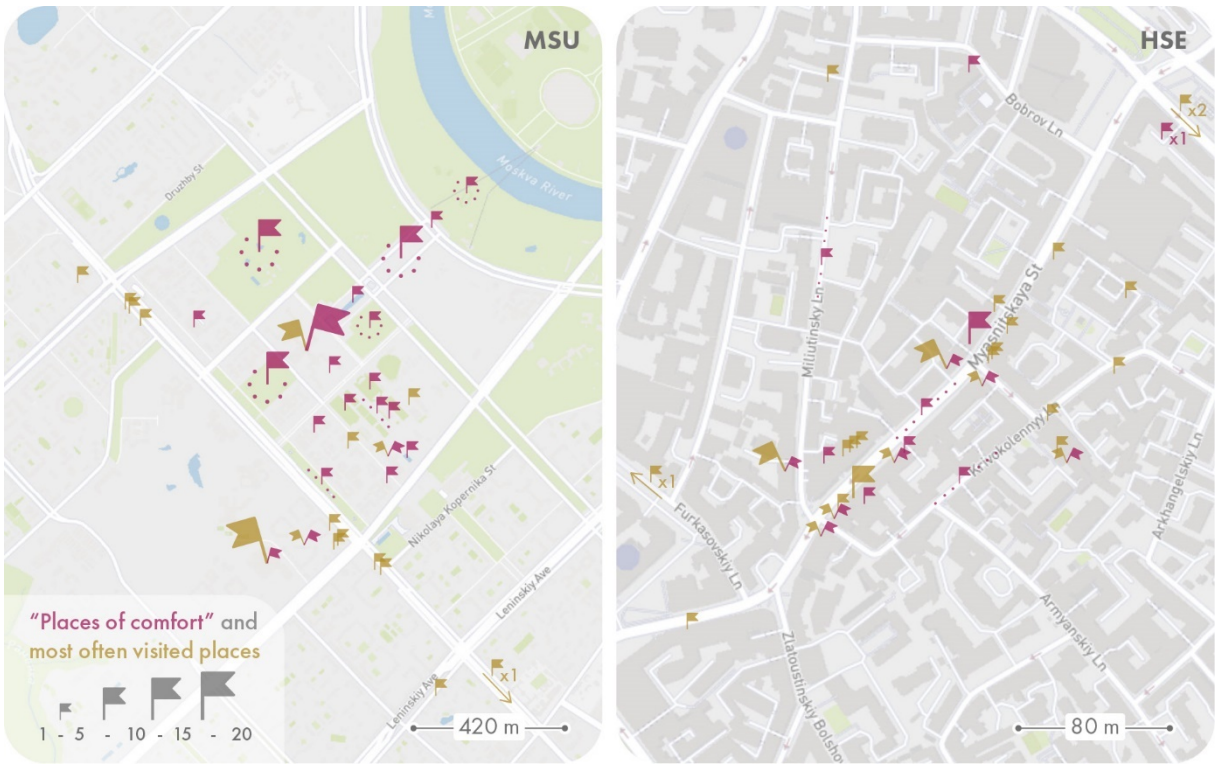


Fig. 3.11. Places of comfort and most visited places on the MSU and HSE campuses

The maps above (Fig. 3.11) combine locations – the places where respondents feel comfortable and the places they visit most often. The idea is to match the functional and "emotional" space of a neighbourhood. The left map shows how many comfort places on the MSU campus are clustered within its domain, while functional facilities – frequented shops, cafés, etc. – mostly stay apart. Inside the HSE campus, everything is mixed: academic buildings and cafés both serve as places of comfort and are frequented by students. In addition, there are fewer pronounced dominants; important places are scattered along Myasnitskaya and adjacent streets. Functional places and comfort zones can help to verify the spatial extent of a neighbourhood and to localise its centre.

Seemingly simple question about the nicknames of the university area in general and different places within it provides an interesting insight: this might be a bit speculative, but it looks like more than a coincidence that the strongly centred and solid MSU campus has nicknames for its main building and certain places and parks around the campus (see Fig. 3.12). At the same time, the linear HSE campus has nicknames for its main street and some areas around it. Presumably, important features of a neighbourhood (which contribute to its configuration) find their reflection in local "folklore" and aliases.

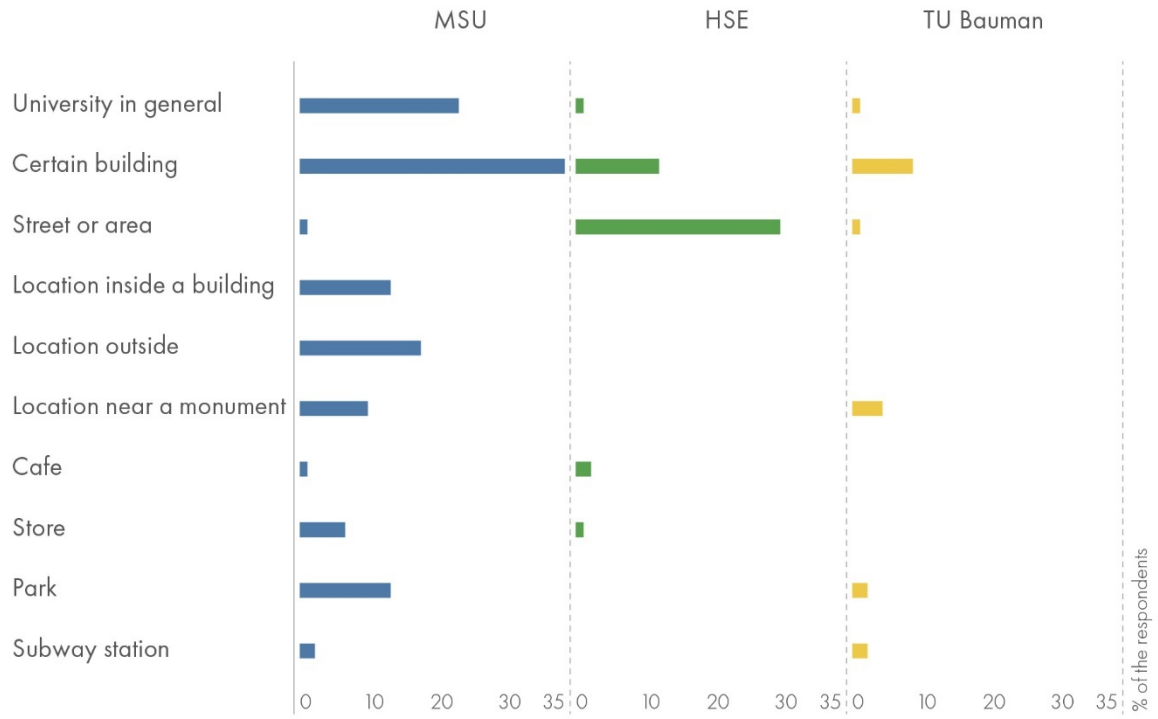


Fig. 3.12. Places given a nickname within each of the neighbourhoods

3.4. Discussion

Despite the original plan to collect 50 responses from each institution, it turned out to be easily done only in social groups with existing social connections and acquaintances: with the help of former fellow students reposts, the number of people from MSU who participated in a survey reached 53 in a matter of days. In HSE and especially TU Bauman, where it was just a questionnaire flickered in a newsfeed, the number of responses is significantly lower.

Since most of the responses came as a result of reposting the survey on social media, the respondents turned out to be people from a similar educational background: students, teachers, and graduates of the MSU Department of Geography, a number of MSU biologists, and also HSE Urban Studies Department students and teachers. On the one hand, it gives us a coherent group of respondents who have comparable impressions of their territory; on the other hand, we must be aware that we only see the perspective of one group of people, whose everyday life is tied to certain locations. As one respondent correctly pointed out while answering the question about the centre of the district, *"The main building, the exit to the observation deck on the Vorobyovy Gory, and the sports grounds where the arena are the core of MSU. But it's a stretch. It's hard to say. Basically, each department and building have their own core."*

3.4.3. The Moscow State University campus

The MSU campus stands out as having the clearest geometric boundaries. Crisp spatial boundaries run along Lomonosovsky, Vernadsky, Universitetsky, and Michurinsky avenues

– this rectangle, it would be fair to call it “the old campus”, was outlined by at least 80% of those surveyed. Not surprisingly, this part is also physically standing apart, enclosed by a high old fence.

The Big Lawn and an unnamed park area across the street are also included in the neighbourhood. It is interesting to note that respondents include one or the other and occasionally both of these parks in their neighbourhood, and only on University Square, a buffer area between them, opinions converge – as a result, it visibly stretches from the MB to the observation deck. Officially the Big Lawn was run by MSU until 2014, when it was handed over to Gorky Park, but stylistically, in naming and in spirit – it does gravitate towards MSU.

In the case of the above-mentioned parks, we dealt with the “native” MSU grounds, which due to their remoteness and non-academic character perceived as an MSU neighbourhood by only half of the respondents. The opposite story is related to the area to the south-west of the old campus, the university's new development site. The centrepiece of the ensemble, the Fundamental Library, was opened in 2005, but has never been massively visited, while the newly built Lomonosov and Shuvalovsky lecture halls nearby clearly do not evoke warm feelings of attachment amongst locals *(“the buildings to the south of Lomonosov Avenue are too ugly to remember” – a participant of the survey*). I would assume, however, that the recent construction of a new student dormitory on a former wasteland behind the library will at least logistically tie the area to “perceptual MSU”.

While the library and the new buildings are perceptually detached from MSU, even though they formally belong to it, the far more distant Capitoly shopping centre is included in the neighbourhood by many. It is explained by its functional significance: there is more than just academic buildings on campus, but also student dorms and some apartments; and there are simply no other stores and proper cafes in the vicinity. *("The Capitoly shopping mall is definitely within [the neighbourhood]"; "An important part besides the university campus is the Capitoly, where many students spend their time and those who live in dorms shop for food"*). The mall and the road to it stand out prominently in the southwest of the district, and although it's not an undisputed part of MSU neighbourhood, it was noted by almost as many people as the new buildings beyond Lomonosovsky avenue (~35% and ~45%, respectively).

The boundaries behind Vernadsky avenue are blurred – it is more of a functional extension, tied to the neighbourhood by underground exits, the road to the Capitoly and landmarks like the Circus. In the distance the neighbourhood is fading out; only individual respondents extend it to Leninsky Avenue, Mosfilmovskaya Street, Ramensky Boulevard and the Moscow River embankment.

The centre of the campus is the rectangle around the Main Building (hereafter MB) and its courtyards with adjacent streets, with the focus point facing the Library and Lomonosov monument (“club entrance”). Official main entrance is opposite the Vorobyovy Gory, but in reality, it is more often used as a back door to a lounge area and parade exit to walking streets. De-facto, the main entrance is definitely in the side of Lomonosovsky Prospect: *"Life on the steps of the main building is boiling", "I would also single out an island in front of the exit from sector A", "the smoking spots at the exits from the main building (the Cultural Centre and to Vorobyovy Gory) – the very centre", "The focal point of everything: the steps in front of*

the exits of the MB on Akademika Khokhlova St. (so called club entrance) and the "puck" with buffets inside".

It is possible, however, that the result is influenced by the fact that the participants are mainly graduates of the Geography Department, which is located in the MB. Possibly, if we conducted a survey among biologists whose faculty is located in another building, the result would not be so unambiguous.

That is, the location of the centre is conditioned by a number of factors:

architectural: where else to be the soul of the neighbourhood but on the steps of the most beautiful high-rise;

transport: there is a public bus stop there, parking, etc.;

functional: inside the building, the core continues with the “puck”, a place where students hang out at every break; the locker rooms, elevators, entrance to the swimming pool, culture centre – everything is in this bottleneck (in a positive sense);

emotional: through the side doors one enters the same building, but through shabby dorm halls, while the club part is really a parade entrance.

3.4.4. The Higher School of Economics campus

The HSE campus is young and purposefully developing according to its concept of a distributed campus: it is going to be more of a network structure sewn into the city (moreover, the historic centre of the city) rather than compact isolated grounds. Although the whole area between Myasnitskaya, Solyanka Streets and Pokrovsky boulevard in the future is supposed to become the core of this network, it is too early to talk about a unified area formed there; so far it is more plausible to consider individual clusters. The focus of this study is the Myasnitskaya cluster.

In the relatively isolated MSU campus, wide avenues serve as boundaries of the neighbourhood; at the same time, in the city centre old streets and alleys serve as axes along which the neighbourhood is formed. With little help, perhaps, of the reconstruction of Myasnitskaya Street in 2015, when it was made more pedestrian-friendly by widening the pavements and narrowing the carriageway.

Most of the neighbourhoods drawn by the respondents are strung onto Myasnitskaya Street; some of them embrace lecture halls and neighbouring residential blocks, but most of the overlaps are on the front facades of the M20, M11, M18 and M13 [footnote] buildings.

The central street is an extension of HSE: it is evident from the shape of the intersections fading along it, “sleeves” stretch in both directions along the street to the Lubyanka and Chistye Prudy underground stations. There is also a noticeable corridor leading to the Armyansky Block, another mini-cluster of HSE in Armyansky Lane*. “But it's all perceived as a whole, even if it's made up of corridors.”* Thus, the perceptual neighbourhood stretches from its centre on Myasnitskaya Street towards Pokrovka and Armyanka clusters, but has not yet reached them.

Last and possibly least, an article [link!] in The Village magazine about an informal café recently opened in the courtyards of Myasnitskaya mentions that *"it is nice to come here and sit down to write a thesis or just have a cup of good coffee",* which in itself does not prove it, but hints that a surrounding area is shaping up to be student-centred.

When it comes to highlighting the core, the central street itself is delineated again even more often than the main buildings. But, together with frequently visited cafés, they share the popularity:

"The core areas are undoubtedly the main blocks (M20, M11, M13) on Meat (and the key eateries in between)"

"At the porch on Meat 11 everyone is standing around: either smoking or just talking"

"Starbucks in the 9/11 block and eventually (because there wasn't enough space in Star anymore) the Karavaev brothers' cookshop"

"There's a triangle at the crossroads where everyone meets before the classes start and where they go during breaks"

According to the maps and comments both, the triangle in front of M11 – the front entrance to the building – is an absolute focus of social activity. The validity of this conclusion will be tested in the evaluation survey.

3.4.5. The Bauman Technical University campus

There is not enough data on TU Bauman to draw confident conclusions, but one can see a "yoke"-like structure, with Laboratory Building and the Main Building on Lefortovskaya Embankment at the ends, between them are the buildings of the power engineering and special engineering departments, dormitories, canteens and other auxiliary facilities. The sports complex on the opposite bank of the Yauza River is slightly less pronounced. Outside the campus grounds, a noticeable corridor runs along pedestrian Ladozhskaya Street, a hub of cafeterias and eateries, a portal to nearby bars, and a road to/from Baumanskaya underground station.

Even a few collected comments caught an expression of topophilia: *"Even the air there seems somehow special to me. When I go there, I walk and smile all the time."* The core is identified as the historic Main building and the courtyard behind it, it is the place where all of the centre polygons overlap.

This prestudy has helped to create a foundation for the major research by answering the RQ2.1 (Which types of geographical features strongly contribute to the inner structure of a neighbourhood? (e.g., amenities, core and boundary, functional aspects, etc.)) and, partly, RQ3.1 (How to identify the core, the boundary of a neighbourhood and different amenities within it?). It was important to give a context to the study before proceeding to more rigorous quantitative methods outlined in the next chapter.

4. Methodology

4.1. Visualisation Technique Development

4.1.1. Visual variables employed in the technique development

A number of visualisation techniques were developed as part of this research in order to answer the research questions RQ1.3 and RQ2.3. The techniques were implemented by using a combination of ArcGIS Pro and Adobe Illustrator; the background map is pre-designed in Mapbox and added to the ArcGIS project as WMTS.

All the developed techniques are based on the same data retrieved during the pre-study: a polygonal cells layer containing the percentage of the respondents who claimed each cell a part of their neighbourhood. By arbitrarily choosing a threshold, the core, domain and sphere areas were extracted for each of the neighbourhoods (for a detailed description, see section 3.3.2).

The visualisation of fuzzy sets and uncertainty has received certain attention in the scientific literature (e.g., Fisher et al., 2006, MacEachren et al., 2005, Roth, 2009), so we can employ some findings of the previous scholars. It is common to start with visual variables when selecting proper cartographic means for such regions (Thomson, 2004). According to the experiment conducted by MacEachren, variables most suited for uncertainty depiction are crispness and location, followed by value, arrangement, size, and transparency (MacEachren et al., 2012). Since this study is dealing mostly with fuzzy objects rather than uncertainty depiction – although these two concepts are related – we can take these findings into consideration, but still can observe the whole set of variables and select the elements suitable for neighbourhood's depiction. The overview of these variables is presented in the table 4.1.

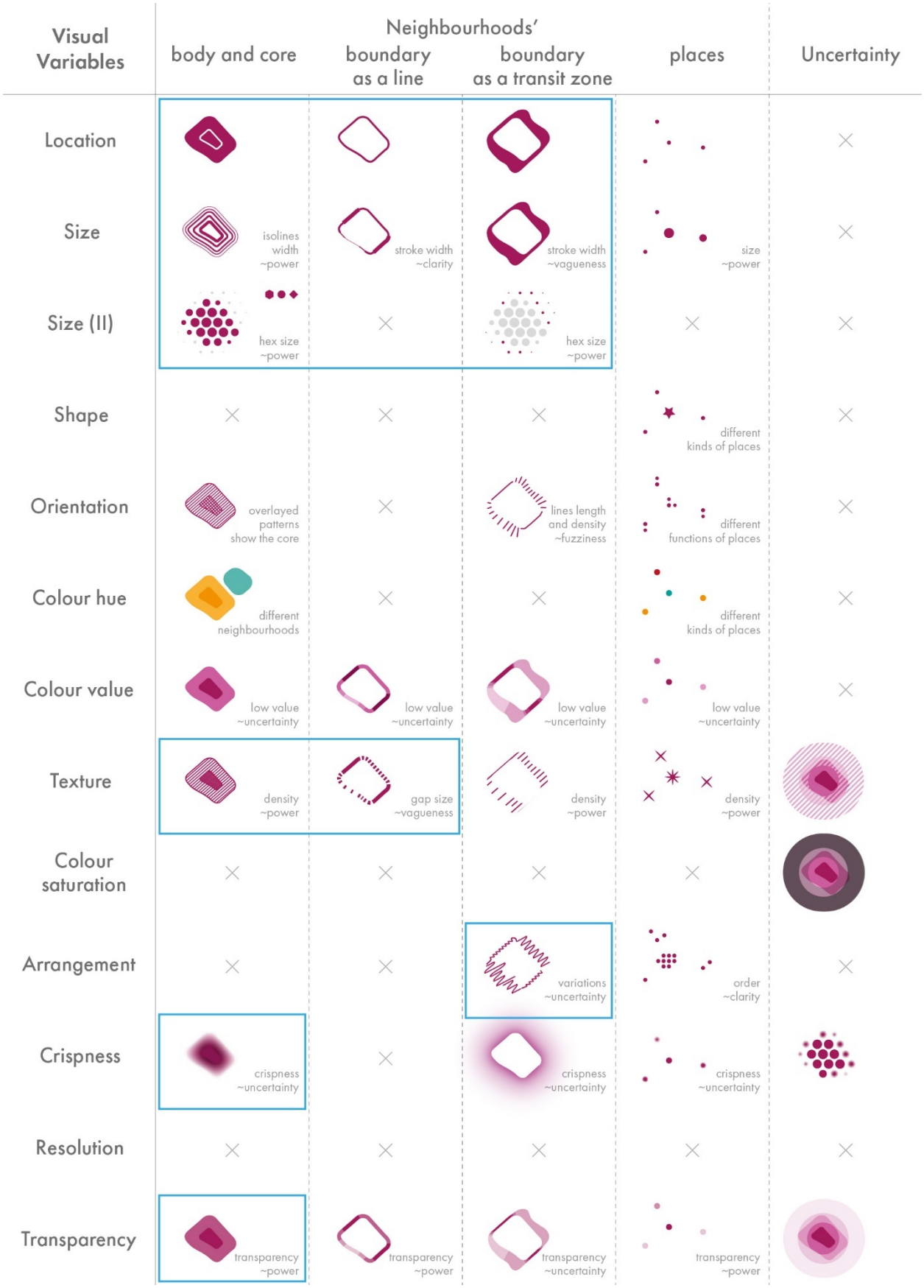


Table. 4.1. The visual variables considered in the maps design

By applying various symbology, we can emphasise on either the body of the neighbourhood or its boundaries, therefore the table distinguishes between these different focuses. Also, possible visualisations of places are included as well as some assumptions regarding uncertainty information. Not all of the theoretically-suitable techniques shown in the table can be applied to the current case: selected neighbourhoods are rather isolated so employing different colour hues would not make any sense; changing colour value without reducing transparency would block the basemap, orientation and texture partly duplicate each other, etc. The selected techniques are outlined with blue frames, various combinations of those we will compare in the following section.

4.1.2. Map styling

This subchapter presents twelve visualisation techniques which were developed based on the assumptions and estimations explained in the previous section. Based on the same dataset, the techniques although have different focus – they either highlight boundaries or the neighbourhood itself. All of the following examples were included in evaluation to test how intuitive they are, and which visualisations are more appealing for the users.

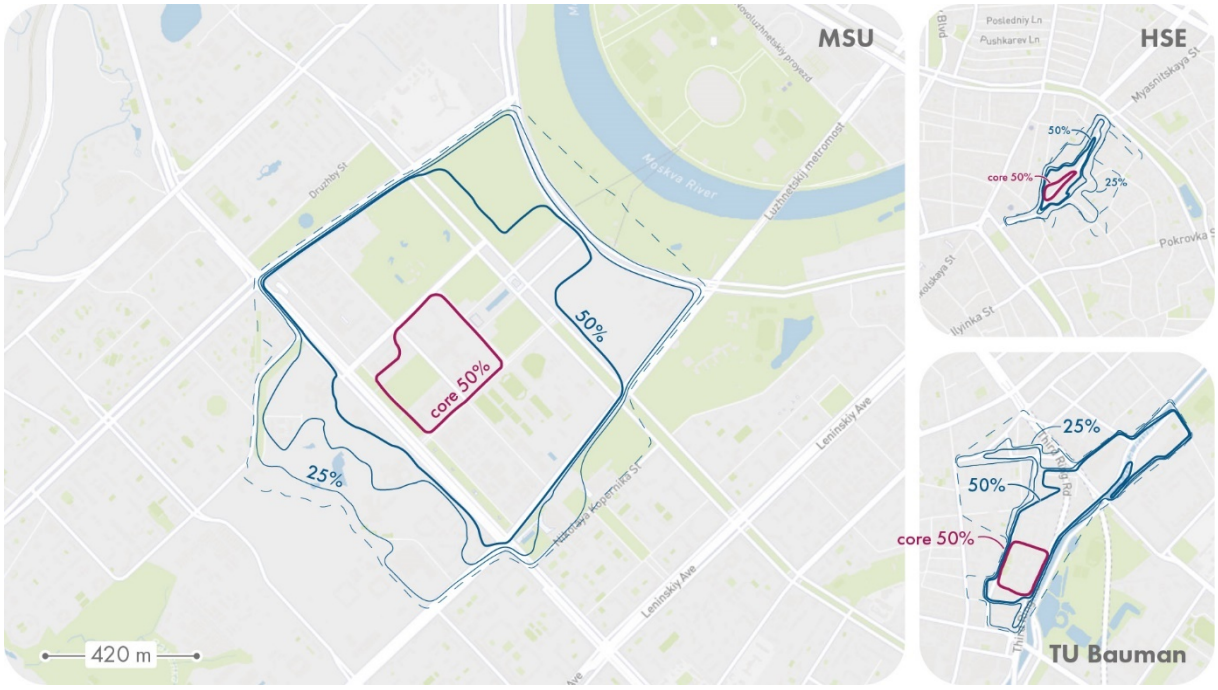


Fig. 4.1. Contour lines technique

If we consider a neighbourhood as a surface of varying recognisability, the obvious choice of visualisation technique which would convey this variation is a set of contour lines. Different colours refer to the two datasets (the core and the neighbourhood separately), the thickness of the line indicates how pronounced the neighbourhood is in each point. The positive feature of this method is that it does not block the basemap and potentially allows overlap with other neighbourhoods (although, depending on its inner complexity, overlapped areas might look cluttered). The method is also informative, despite being simple: it is not a black box, it honestly shows how the lines were defined. If there is a need to implement uncertainty information, it is also possible to modify the technique by either increasing transparency or applying a pattern to a line.

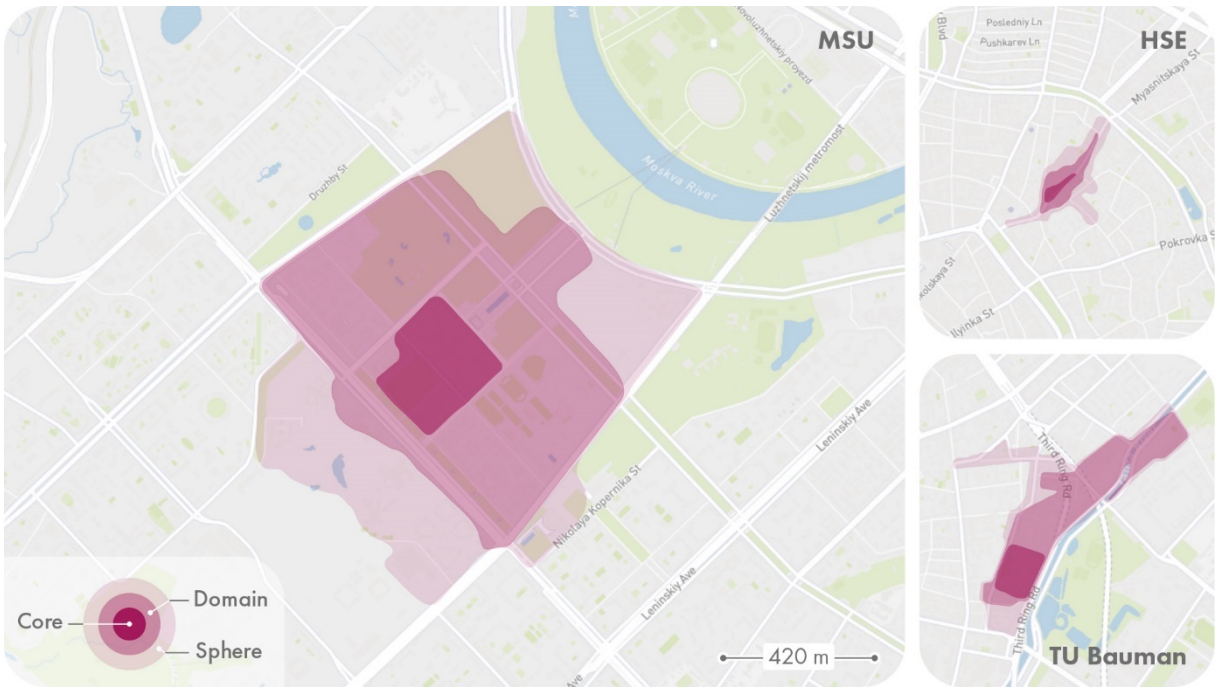


Fig. 4.2. Layer tinting technique

The "default view" presented in the questionnaire is mimicking layer tinting technique. Different subsections of a neighbourhood – the core, domain and sphere – are filled with the same colour with varying transparency to indicate a transition between the most pronounced core area to the outskirts (for more detailed explanation, see the section 3.3.2, "Configuration of the neighbourhoods and their centres"). The method is simple and intuitive, although it might look messy if there are several overlapping neighbourhoods on the map shown in different colours.

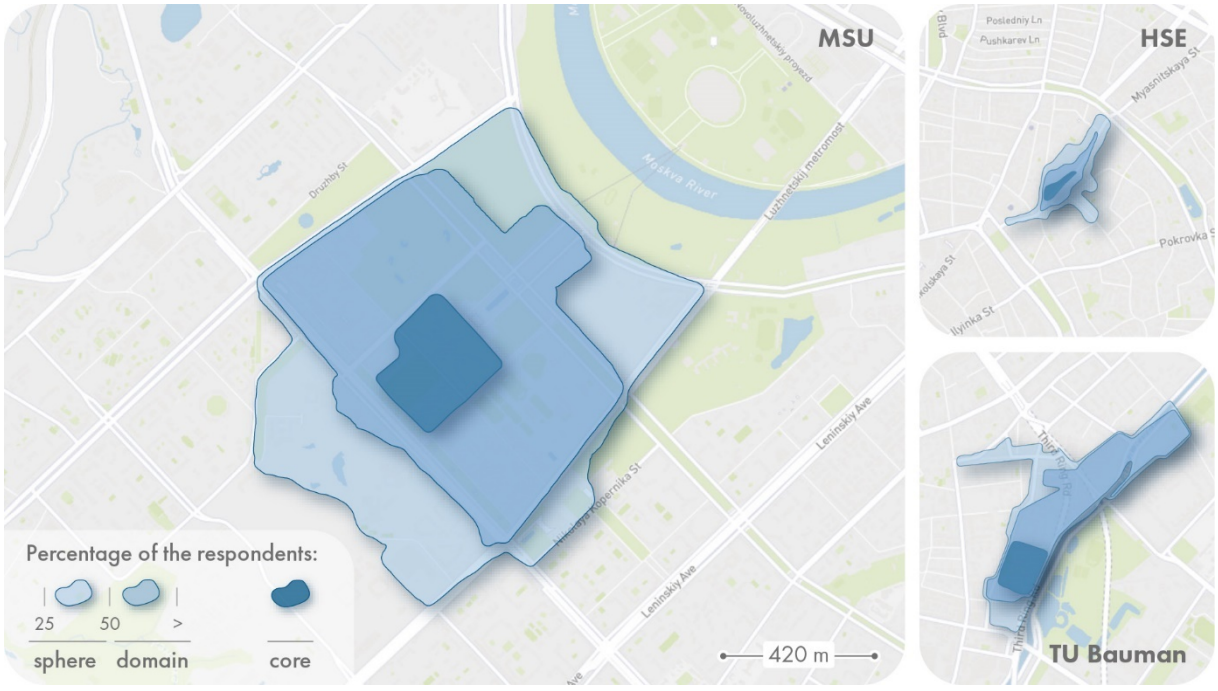


Fig. 4.3. 3D layer tinting technique

Another variation of the previous technique – the same method with a subtle 3D effect. It makes the area stand out from the background and three parts of the neighbourhood are clearer delineated.

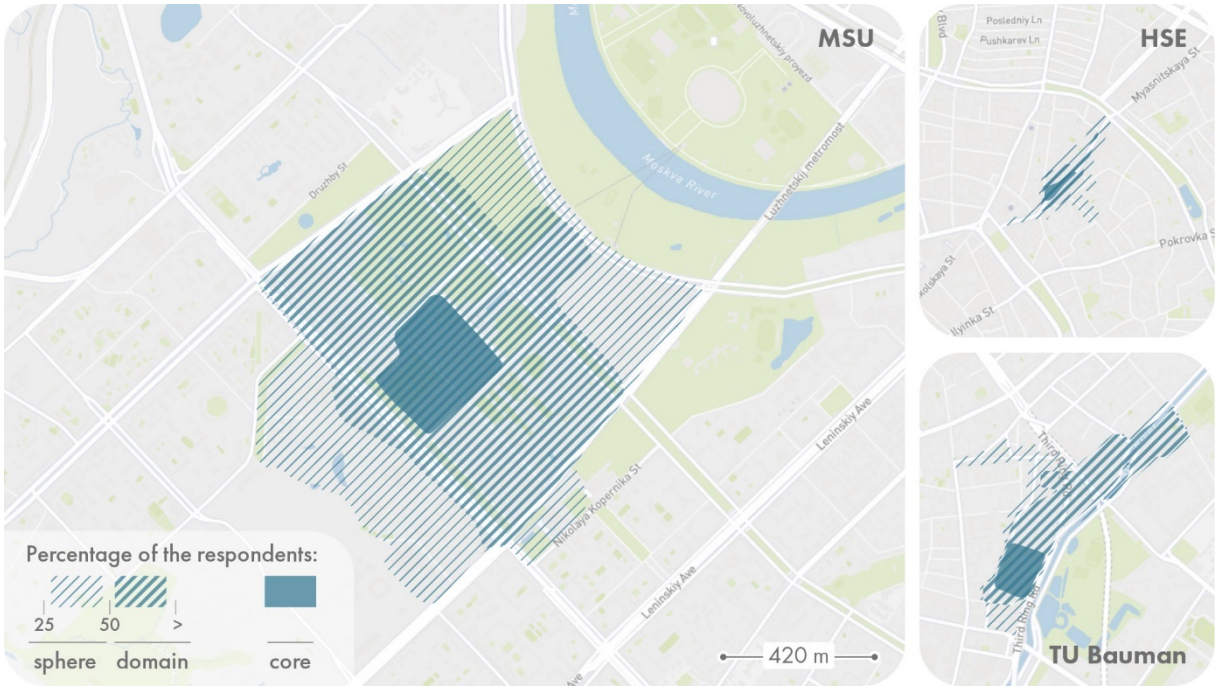


Fig. 4.4. Hatching technique

Instead of filling the polygons with the same colour of different transparency, this technique employs the texture and size variables to indicate different parts of the neighbourhood. The core part is additionally highlighted with a semi-transparent fill. Unlike the previous examples, it allows to show different overlapping neighbourhoods by choosing different colours and an offset for textures.

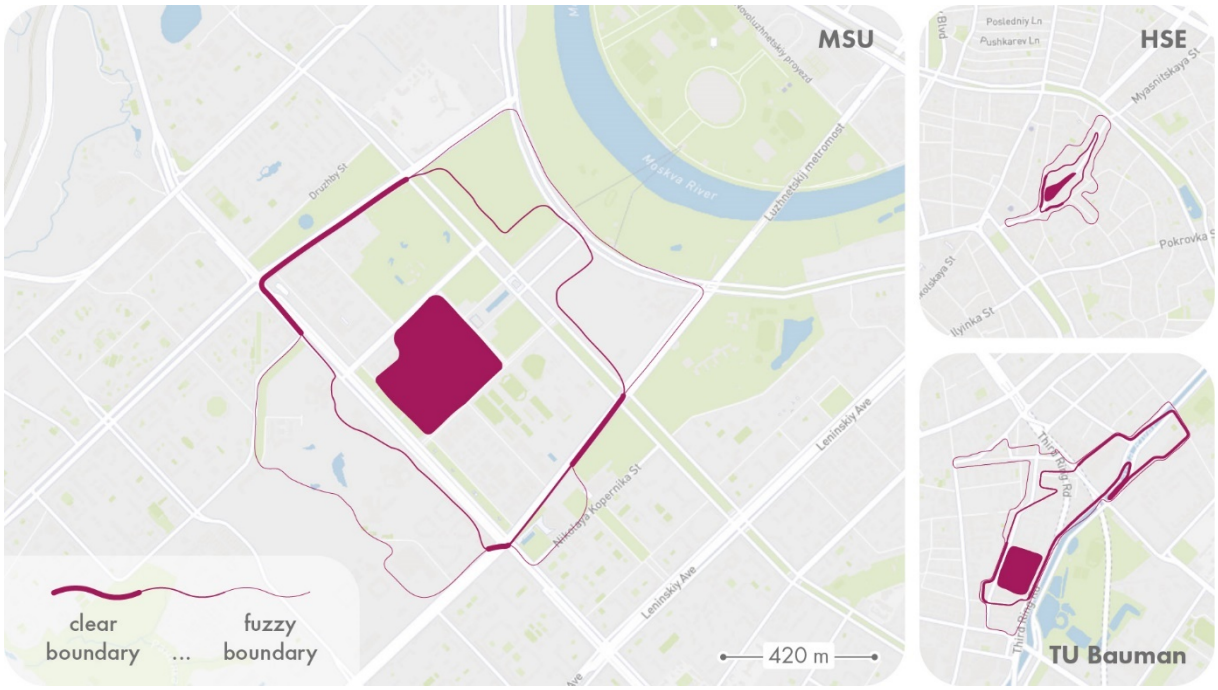


Fig. 4.5. Varying contour weight technique

The original contour lines method can be transformed: the percentage labels were removed, but the qualitative information regarding fuzziness is added. The thicker the line, the crisper the boundary, and vice versa, so the fuzzy boundaries are shown as thin lines. The core area is represented by a simple fill polygon. Thus, the image gives an impression of boldness and certainty in clearly delineated areas and stays almost invisible in fuzzy areas.

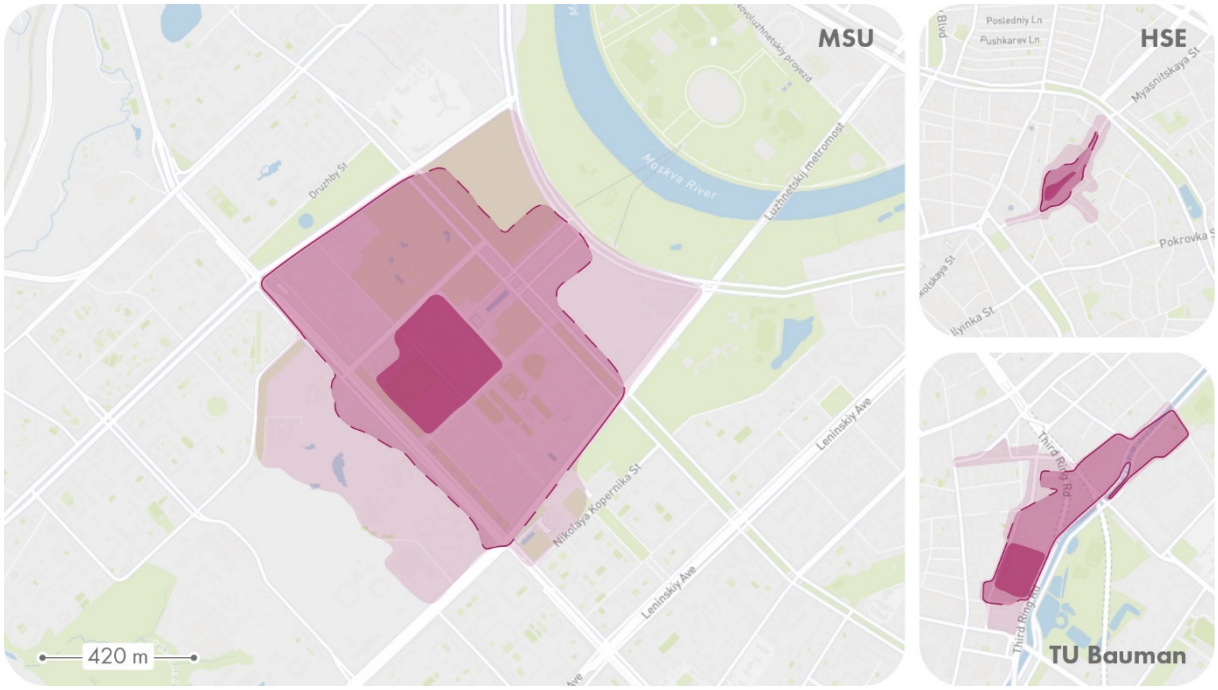


Fig. 4.6. Combined technique (I)

A simple three-transparency-level technique is accompanied with a line displaying crisp and fuzzy boundaries. This combination makes a domain area look more pronounced and allows to indicate the boundary characteristics more explicitly – though, the latter might not be obvious from the look at the map and might require a description in the legend.

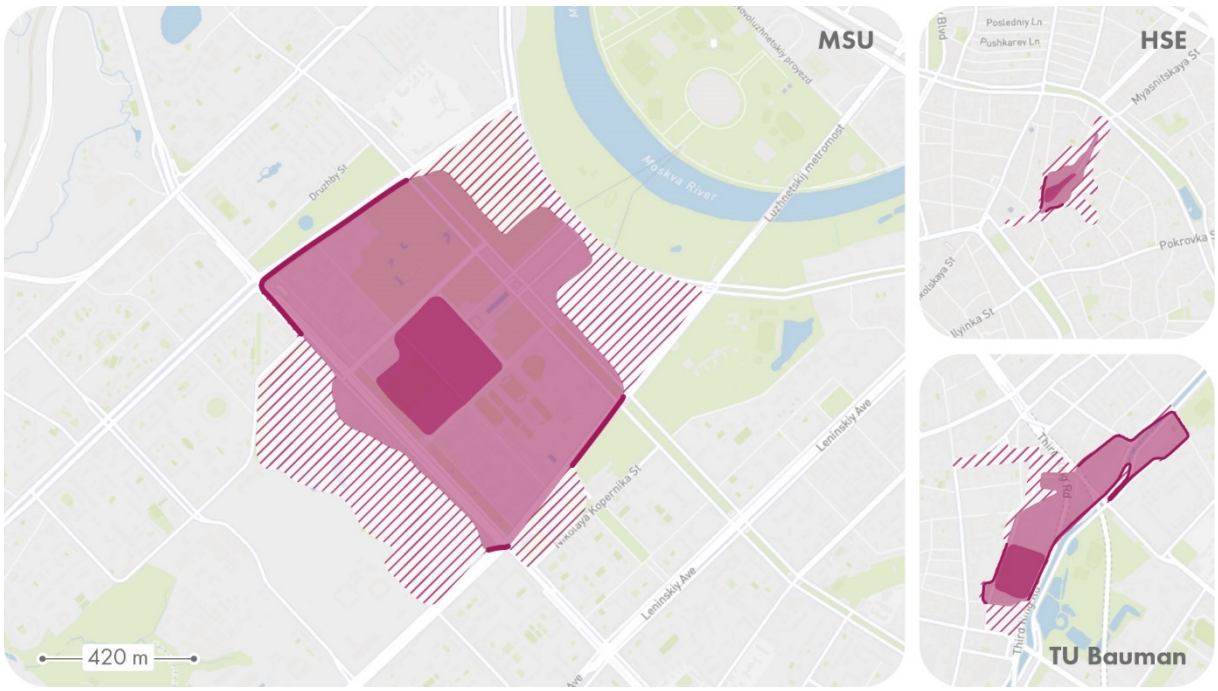


Fig. 4.7. Combined technique (II)

Another combination of previously described methods: the semi-transparent fill for the core and domain areas and hatching for the sphere. Additionally, crisp boundaries are indicated with thick strokes.

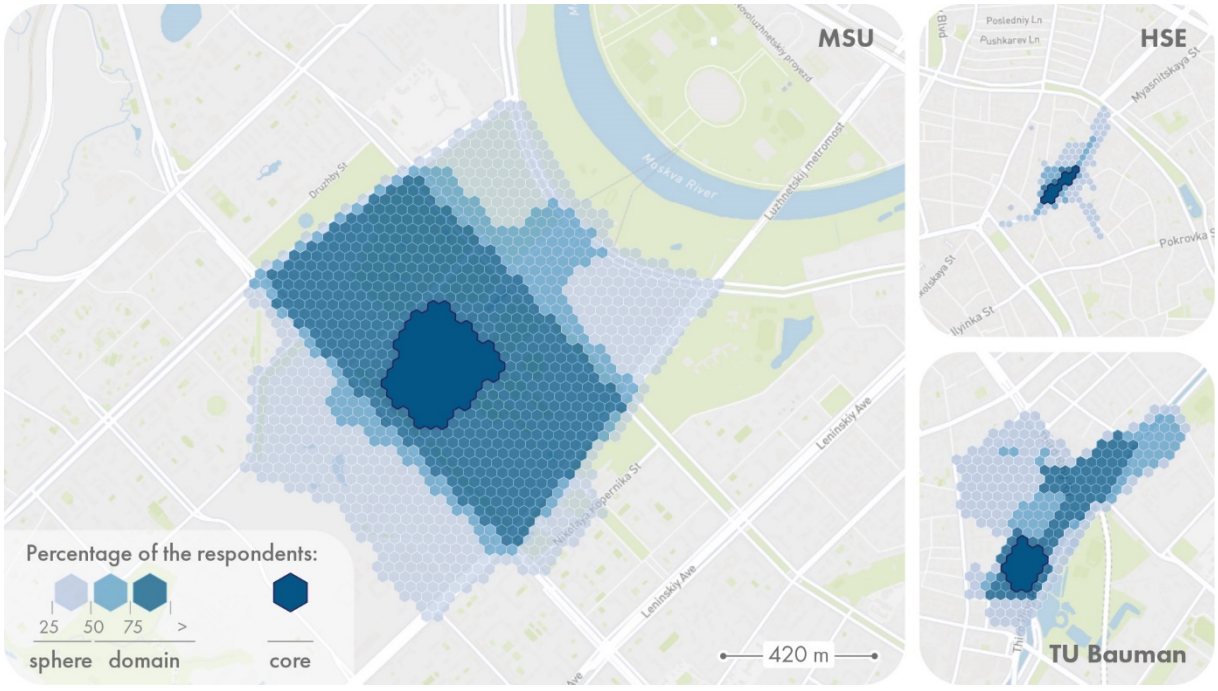


Fig. 4.8. Hexagonal grid technique

From the very beginning, it was possible to use a hexagonal grid instead of small square cells to recalculate the numbers of drawn polygons. The result is easy to understand and the legend makes it clear what different colours mean. Among the disadvantages of this method is that the cell size should be optimal for all the objects: if cells are too large, the shape of a neighbourhood will be distorted.

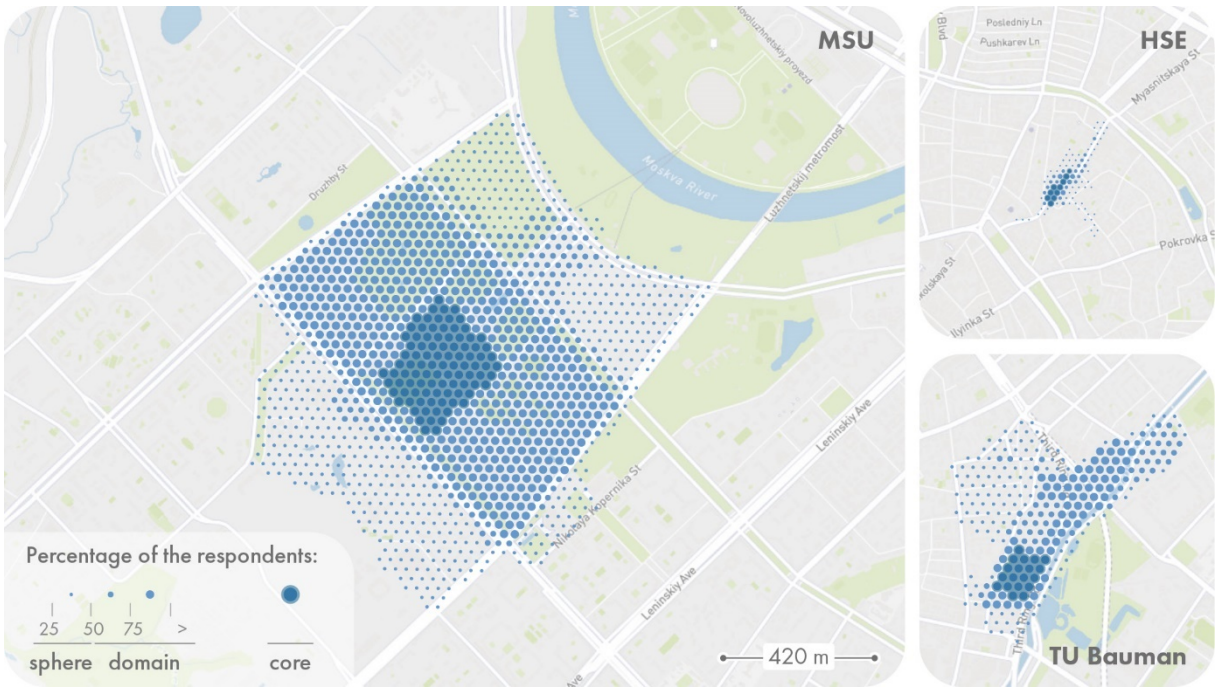


Fig. 4.9. Circles technique

To transform a hexagonal grid into a “lighter” representation, it is possible to place a circle in the centre of each cell so the size of the circle is proportional to the percentage within its cell. The changing size of the circles layer creates a smooth gradient and allows to quickly grasp the neighbourhood configuration. The core part is additionally outlined with a darker layer of overlapping circles in order to catch immediate attention. This technique works particularly well for web maps, but requires changing of a cell size across the range of zoom levels.

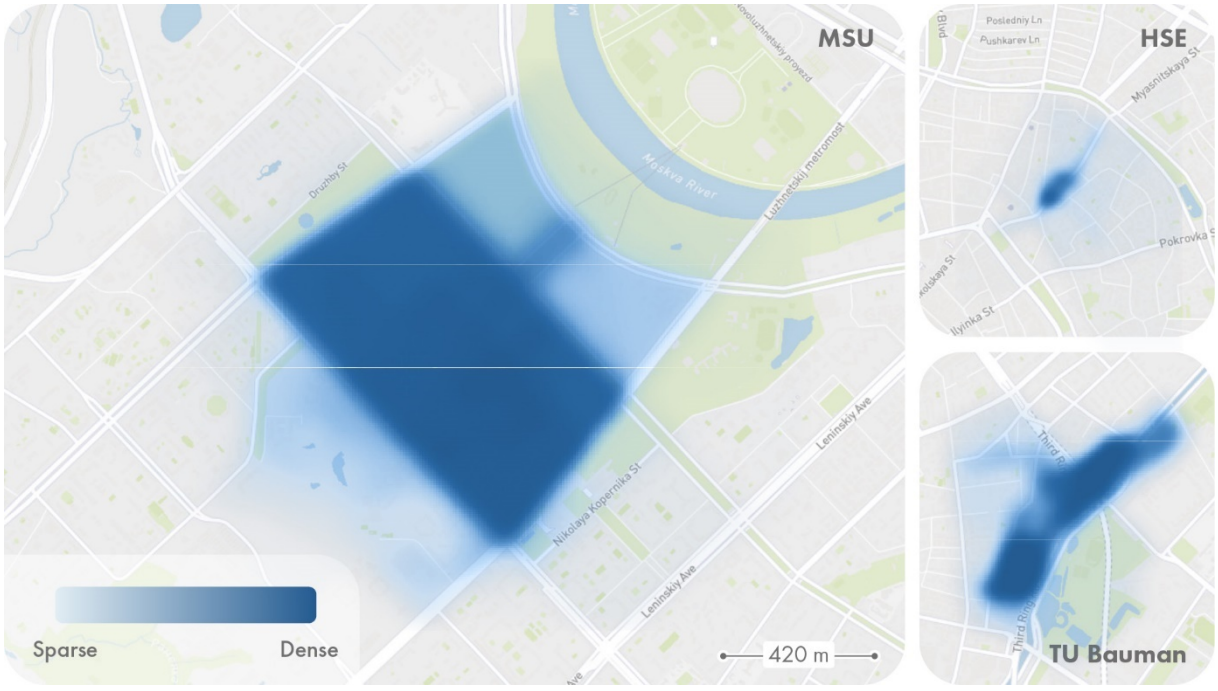


Fig. 4.10. Heatmap technique

A common way of visualising fuzzy sets – a heatmap. It works well in providing a general overview, but it lacks detailing. Presumably, this technique is better suited for creating preliminary visualisations meant for future analysis.

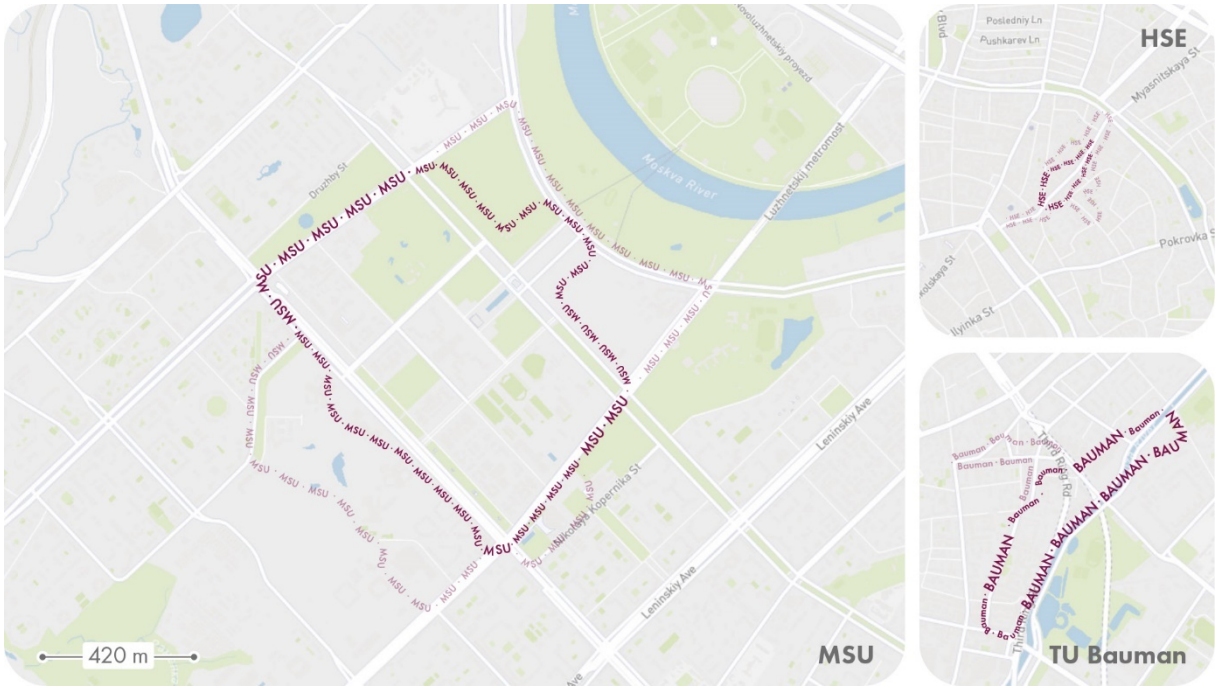


Fig. 4.11. Textual contour lines technique

The next technique is mimicking a popular idea of creating maps of street or river labels. Large font size indicates a crisp boundary, a smaller text – non-transparent and semi-transparent – outlines an inner and outer edge of the fuzzy area respectively. The method is unusual, easy-to-implement and intuitive, although it might be tricky to use it on small districts of complicated shape.

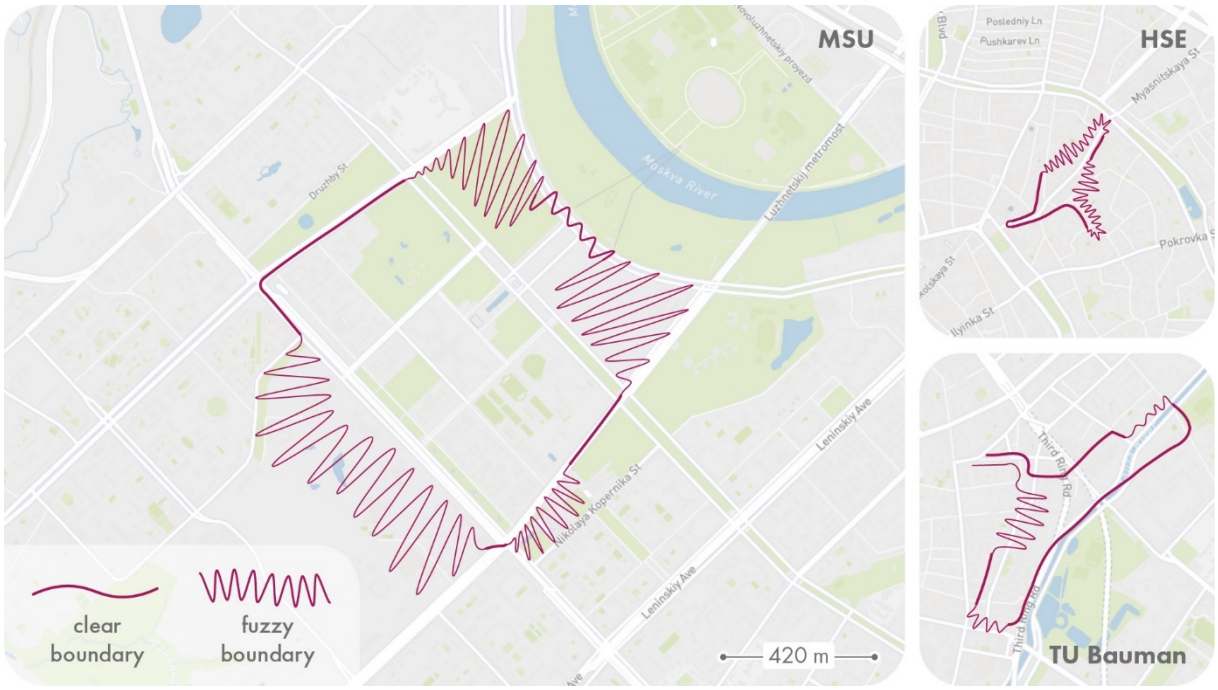


Fig. 4.12. Jagged line technique

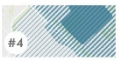
A bit of an unorthodox technique indicates crisp boundaries as straight lines while a sketchy zig-zag line depicts an area where the boundary is fuzzy. Doodle-like style refers to the fact that we do not know exactly where the fuzzy boundary is, so the line crosses this unclear zone.

4.1.3. Affordances of resulting visualisations

The set of the maps described above includes different visualisations of the same object and these visualisations are characterised by varying affordances. The variables most widely used are transparency, size, and texture, as well as location as "indispensable" variable (Rooth, 2016). Almost all the techniques end up as discrete visualisations since it was a part of the methodology to extract certain parts of the neighbourhoods; in rare cases of continuous visualisations the boundaries between these parts were blurred. Only a few techniques allow one to see a basemap, although some only partially block it (with a colour fill core part, for instance). Also, the visualisations are tested on individual isolated neighbourhoods, so not all of them can be used to visualise neighbouring overlapping districts. The resulting visualisations are not completely strict and can be adopted, for instance, by increasing a number of subdivisions or by applying an additional layer of uncertainty information (in this study it could highlight the places where the number of respondents was too low to make confident judgements). The following Table 4.2 shows these comparative affordances.

The table 4.2 allows to anticipate which of the techniques are able to successfully convey neighbourhood boundaries. By the combination of criteria used in this table, the techniques #1 and #9 look the most promising, followed by #2 and #5. However, there is no way to theoretically estimate the intuitiveness of these techniques. The evaluation survey will quantify this missing criterion and compare the predictions with the real survey results.

Table 4.2. Estimated affordances of the visualisation techniques

Visualisation technique	Visual variable employed	Continious or discrete	Clearly differentiates between C, D, S	Allows to see the background	Allows overlap with neighbouring districts	Allows to increase the number of 'steps'	Allows to implement uncertainty information
 #1	location, size	D	✓	✓	✓	✓	✓ (e.g., transparency)
 #2	transparency	D	✓	✓	×	✓	✓ (e.g., hatching)
 #3	crispness, transparency	D	✓	×	×	✓	✓ (e.g., hatching)
 #4	texture, size	D	✓	×	✓	✓	✓ (e.g., transparency)
 #5	location, size	D	✓	✓	✓	✓	✓ (e.g., transparency)
 #6	transparency, size, texture	D	✓	×	×	×	× (will look cluttered)
 #7	transparency, size, texture	D	✓	×	×	×	× (will look cluttered)
 #8	transparency, texture	D	✓	×	×	✓	✓ (e.g., transparency)
 #9	size	C	✓	×	✓	✓	✓ (e.g., transparency, layer of white dots of smaller size, etc.)
 #10	crispness	C	×	×	×	×	✓ (e.g., hatching)
 #11	texture, size, transparency	D	×	✓	✓	×	✓ (e.g., transparency)
 #12	size, arrangement	D	×	✓	✓	×	✓ (e.g., transparency)

4.2. Evaluation of the Techniques

In order to evaluate the visualisation techniques, the second survey was conducted. The survey opens up with a brief introduction into the study topic and the notice regarding personal data which is not collected during the survey. The first section has two questions: the university affiliation which is used as a filter for the following pages and the current status of the participant in relation to the university: student, employee, or alumni. In the latter question the option "other" is also available for those who never worked or studied in one of three educational institutions but are familiar with their campuses.

The second section is designed to verify the neighbourhood boundaries identification method. Depending on the chosen university the participant is directed to the page with a respective set of maps. Each of the two questions presented there consists of four maps, one of which depicts a true neighbourhood (its domain and sphere) or a core, while the others are fake. Residual option "None of the maps is true" is also available. The degree of recognition will be calculated for each neighbourhood based on the survey results.

Preparing absolutely unrealistic fake maps of any random shape would not be very relevant – after all, many of the polygons outlined by the participants looked alike. So, in order to 1) check the recognisability of the approximated neighbourhoods and 2) check the methodology of delineating them some of the fake options were loosely based on the same set of data, but the threshold – the percentage of participants outlined a certain area – was

set differently, for instance. The procedure was not absolutely strict, but there are some principles demonstrated in the following table:

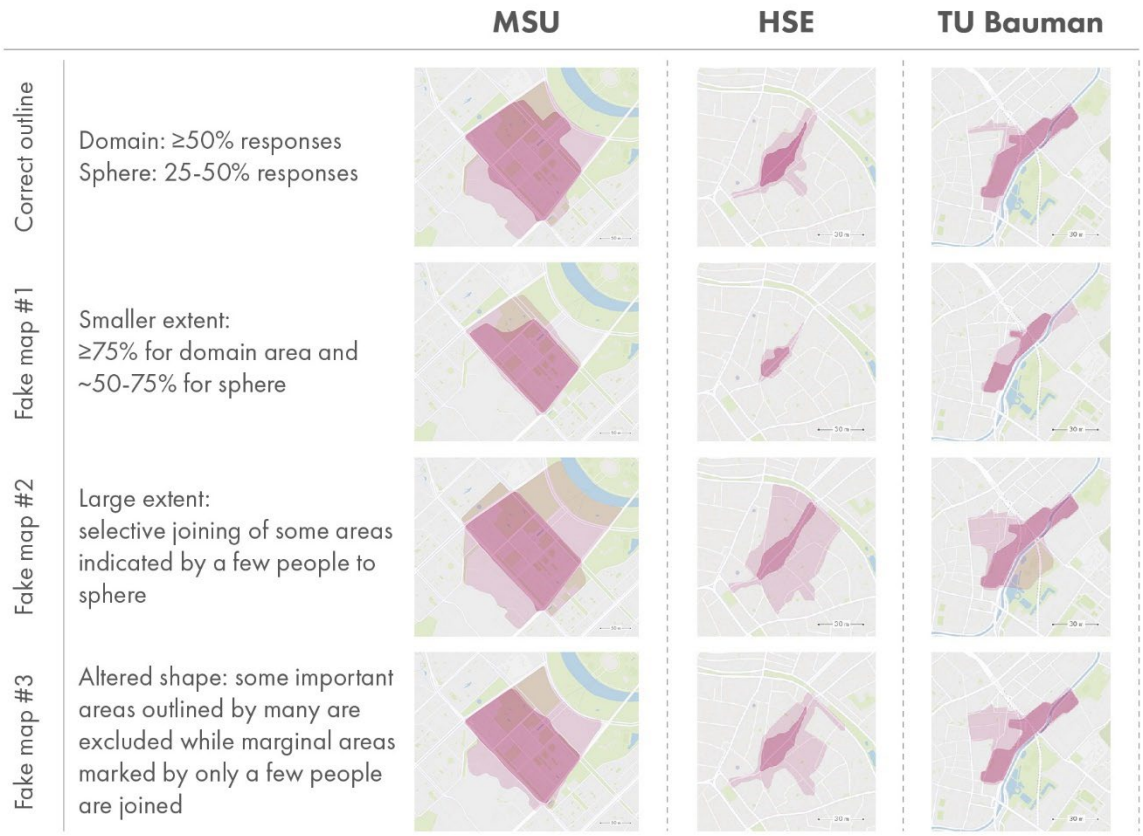


Fig. 4.13. General principles of fake maps design (the domain and sphere parts)

The same applies for the fake cores creation. Some of the participants named their versions of the centres which turned out to be rather individual (mostly this is true for single point locations), but they seemed justified enough to test them in the evaluation survey. Also, it was decided to test the domain and sphere areas separately from core areas since distortions in the core lead to consequent changes in the body outline – the goal was not to mix them.

Fig. 4.14. General principles of fake maps design (the core parts)

In the third section the participant is presented with a task to identify and mark clear and fuzzy boundaries with different symbols on a randomly chosen map. It was decided to show only one example (although it will obviously lead to a fewer evaluated techniques) since otherwise, by comparing different techniques showing the same phenomena, the person would subconsciously perceive the information about it, not test any given visualisation.

Also, the participants were asked to choose how difficult they found the task by marking on a Likert scale among the following options: “difficult, absolutely unclear; all right, but it took some thinking; rather easy; very easy, everything is obvious”. It was intentionally chosen to be four-point in order to differentiate opinions and exclude indifferent neutral responses.

The fourth section is meant to measure subjective perception of the visualisation techniques, to find out which of them the respondents consider more or less appealing. In this question the participants are presented with a set of randomly ordered visualisations of their neighbourhood and asked to choose and range three examples they like the most and at least one they profoundly dislike. (Although, it is mostly a recommendation and they could grade all the visualisations, if they want to). It can be done by marking on an adapted Likert scale:

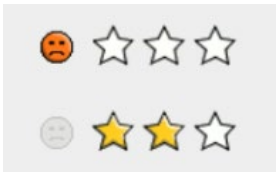


Fig. 4.15. The adapted Likert scale used in the evaluation

The link to the survey was posted on social media platforms including Instagram, Facebook and VKontakte and shared among the author's private network. Originally meant to be opened on computer screens, the layout was eventually adapted for smartphones as well. The survey was available online from September 18th, 2021 to September 30th, 2021. The same as the pre-study survey, it was designed and distributed in Russian. The screenshots with all the pages of the survey are presented in the Appendix N.

The current methodology explained how the visualisations techniques were justified and how they are going to be evaluated. The results of the evaluation are presented in Chapter 5.

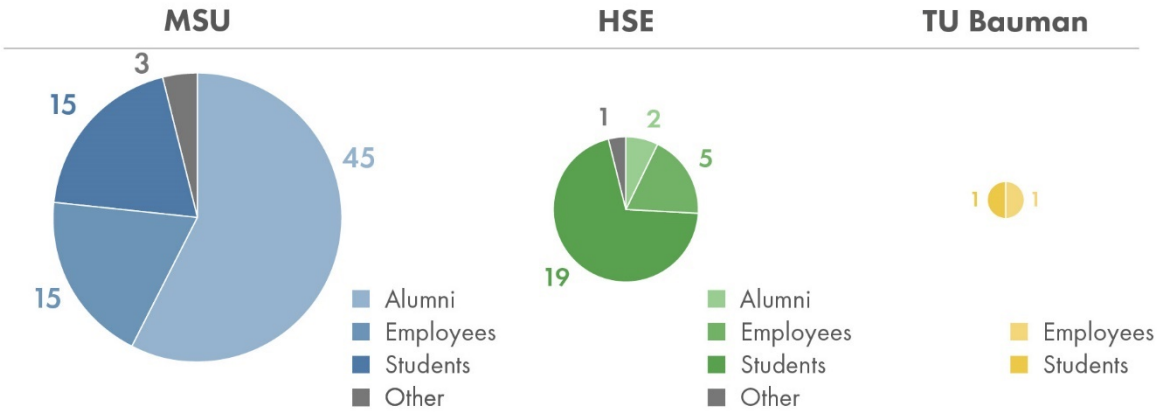
5. Results and discussion

After publishing, the survey had been online for two weeks; it was attempted 169 times and fully completed 88 times (52%). Besides, another 19 respondents (11%) have partly completed it and their answers are also considered in the analysis. This chapter provides an overview of qualitative and quantitative results obtained from the submitted responses.

5.1. Evaluation survey results

5.1.2 Population

The distribution of the respondents between three universities is even more unequal than it was during prestudy:



73% of the participants are MSU graduates, students and employees; there are 78 people in total. 25%, the overwhelming majority of those are students, are related to HSE. Just as in the prestudy, the HSE population is younger in comparison to the MSU respondents. The remaining 2% are affiliated with TU Bauman. This tendency proves the power of social connections: being an absolute outsider to the third university, it appeared to be difficult even to publish a survey in some of their social media pages because it was rejected by the moderators. At the same time, the word was quickly spread among the fellow MSU alumni and – more distant, but still related – the HSE community. Unfortunately, this will narrow the focus of the analysis to the respective two campuses.

5.1.3 Neighbourhood recognition: testing the methodology of delineating perceptual regions

In the second block of the questionnaire, the participants, depending on their alma mater, were presented with a set of maps one of those is true and the rest are fake or distorted (for

more details, see the section 4.2). They were asked to choose the neighbourhood configuration that resembles their own image of the neighbourhood and its boundaries.

Fig. 5.2. Percentage of people who recognised each of the maps as the MSU neighbourhood

Most of the respondents (40%) have chosen the correct map with true boundaries derived from the first survey data. Although, the numbers for the third and the fourth options are also relatively high – 21% and 23% respectively. Those two maps are not a complete lie, but they assign more surrounding area to the neighbourhood, including The Vorobyovy Gory park (fake map #2) or shrink the domain and sphere areas (fake map #3). Fake map #1 eliminates an unpopulated, but inherent part of the campus from the domain and only a few people (9%) recognised this reduced area as MSU neighbourhood. The option "none" was also available; the reasoning of those who picked it reflects the survey limitations explained in section 3.4. Two people noticed that *"the Student House Branch area is missing",* meaning one of the university dormitories beyond the Lomonosovsky Prospekt underground station. It is previously noted that most of the respondents were students and alumni of the Department of Geography, none of whom ever lived in that dormitory; given the fact that it is a rather distant area they do not include it into their neighbourhood. Another comment relates to so-called "new territory" across Lomonosovsky Avenue: it is also explained in the Discussion part of the presudy that most of the participants tended to deliberately exclude it from their neighbourhood.

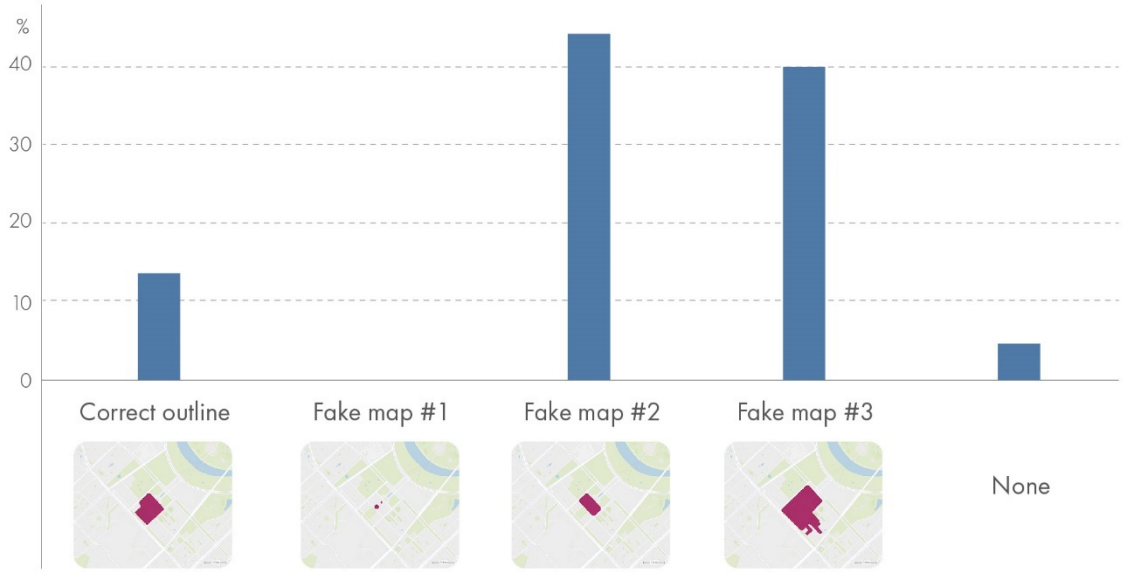


Fig. 5.3. Percentage of people who recognised each of the maps as a centre of the MSU neighbourhood

The same question, but related to the core of the neighbourhood, exposed a controversy between the geographical data obtained during the prestudy, and written comments. Despite the fact that the core map is based strictly on the outlines drawn by the participants, the degree of recognition is dramatically low – 13%. The high recognition of the fake map #2 is possible to explain though: to create the core outline as it presented on the "correct map", it was chosen to set up a 50% threshold, meaning "the area marked as a centre by more than a half of the participants". At the same time, the fake map #2 is a result of shifting the threshold up to 70% – meaning it is the same dataset under another filter condition. The resulting rectangle appears to be more solid and also coincides with the geographical centre of the campus.

The popularity of the fake map #4 is a bit harder to explain: this map was based on written comments which assigned buildings and alleys between the MB and Universitet underground station to the core. Apparently, perception of all this area as a core is more widely distributed than it seemed on the basis of the survey data.

The comments for the option "none" are of the same nature that they are in the previous question: the population is shifted, so certain areas which current participants consider a centre, are not included into the core.

Fig. 5.4. Percentage of people who recognised each of the maps as the HSE neighbourhood

For the HSE neighbourhood, there is a similar trend: 44% of the respondents chose the correct version of the map. The second popular choice, fake map #2 is clicked by 33% of the participants, represents a very similar neighbourhood, slightly enlarged with adjacent streets repeatedly included into the neighbourhood as corridors to other HSE buildings and appearing to be a logical extension of it. The fake map #3, which outlines only the major university buildings and extends along Myshitskaya street, was not chosen by any of the participants.

One more time, the answers to the question about the core hide the adjustment to the methodology. While the "correct" core was chosen only by 30% of the respondents, its extended version (fake map #3) appeared to be more popular and gathered 52%. Again, this map represents not a completely made up shape but the same dataset with a changed threshold. In this case it was lowered to 30% to include all the central buildings, not just their facades and a part of Mysnitskaya street. Fake maps representing only the focus point – the crossroads in front of the main entrance – or only the main street have been chosen only by a small number of people.

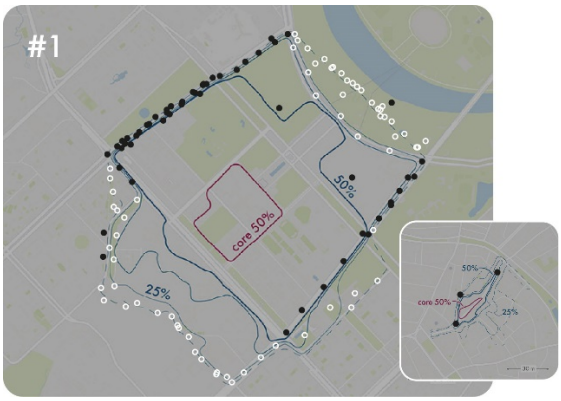
According to the results, we can make a cautious conclusion that the chosen methodology works well for delineating neighbourhood boundaries, but identifying the core part needs adjustment. It cannot be based merely on overlapping polygons drawn by citizens: identifying the concrete places with shared attachment and importance for community is able to contribute even more to the neighbourhood study.

5.1.4. Identifying crisp and fuzzy boundaries: testing the visualisation techniques

In this section maps were presented to the respondent. Only one map randomly drawn from the set of twelve visualisation styles was shown and the participants were asked to identify clear and fuzzy boundaries by placing markers from two different sets along them. The maps were intentionally presented without a legend in order to test how intuitive the visualisations are. Resulting point clouds were plotted on the respective maps. Unfortunately, not all of the maps got sufficient amount of user data to work with: two maps from the set were either never drawn or ignored by the respondents.

The following table summarises the results of the experiment. All the images are scaled down; semi-transparent grey fill is added to highlight the points placed by the participants. Black dots stand for clear boundaries, white outline dots – for fuzzy boundaries.

Table 5.1. Crisp and fuzzy boundaries identified by the participants



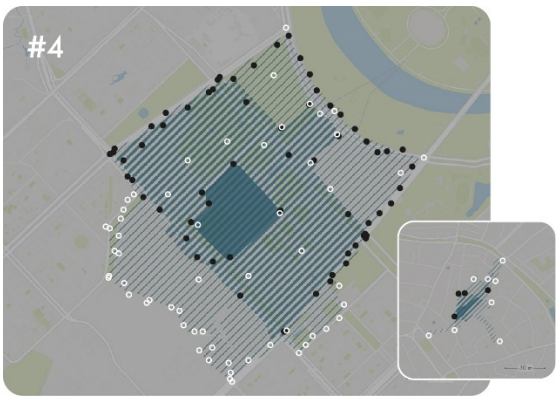
The contour lines method showed a decent result. Both crisp and fuzzy areas identified correctly at least on the MSU map.

On the HSE map, the number of points is insufficient for a proper analysis, but, according to the point in the north-west altogether with single points on the MSU map, we can assume that a thicker 50% contour line can cause certain confusion. Overall, the method works well.

One of the users appreciated this map as the most informative in the whole set.

Unfortunately, no data is available on this map – it was either never drawn or rejected by users.

The 3d layers technique performed rather poorly: many of black dots mark the correct crisp boundaries, but a lot of them are also dispersed across the whole neighbourhood. Hollow dots representing fuzzy areas tend to be clustered in the right locations, but they are unjustifiably scattered within the neighbourhood, too. Apparently, clear shapes of 3d layers cause confusion and are not suited for visualisation of vague objects.

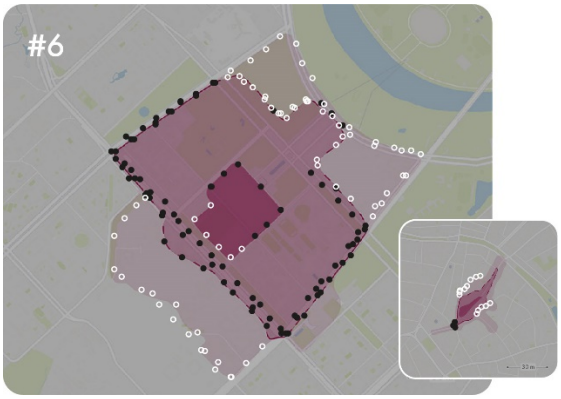


The hatching technique did not provide a good result overall. The fuzzy area in the south-west identified correctly, the north-eastern part, although sharing the same symbology, is marked as a clear boundary: how the boundary is perceived does not only depend on symbology, but on its geometry as well.

For some reason, random points are scattered inside the neighbourhood. In the comments this map was also called *"visually aggressive"* by a user, who although made a remark that maybe lowering the contrast would make it look softer.

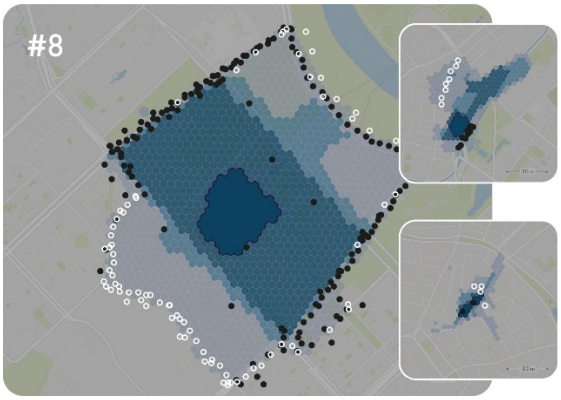
Unfortunately, there is not enough user data collected on this visualisation, but the points left on the HSE map are placed correctly.

Although, it is not possible to draw confident conclusions from that.



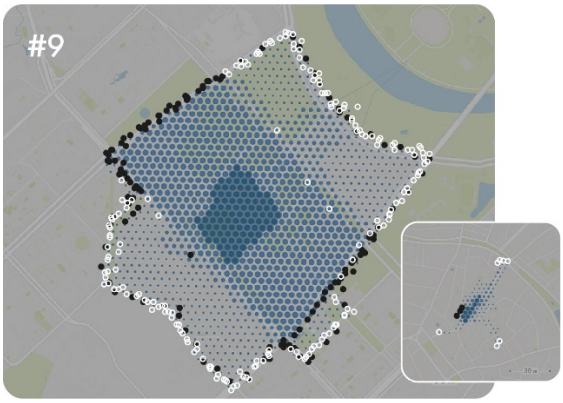
The map represents a combination of different methods – varying transparency fill and solid/dashed lines – where one part of the neighbourhood visually prevails over the over. This allows to emphasise on the domain part, but causes certain confusion: the fringe between domain and sphere is often identified as a crisp boundary, which is not what was intended. Also, the boundaries carrying the same symbology are marked as both crisp and fuzzy, which reflects a bewildering effect this visualisation has on users.

The combination of semi-transparent fill and hatching allows to identify fuzzy areas correctly, but, when it comes to crisp boundaries, the visual emphasis on the domain part prevails and makes the users perceive the whole domain's boundary as crisp. Just as in the previous example, marking hard boundaries with a separate symbol – a thick line – did not significantly influence the users' behaviour.

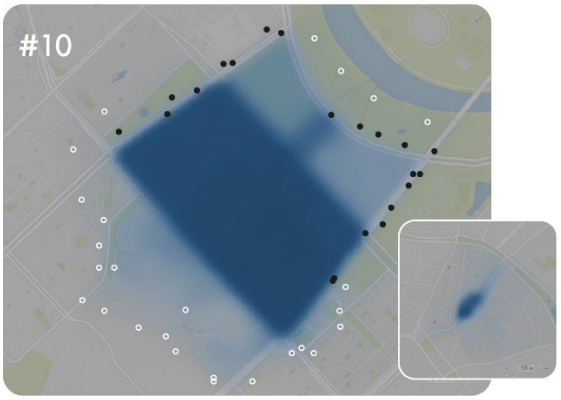


On the hexagonal map the fuzzy areas are identified correctly, although the south-western part is marked more confidently than the north-eastern. The north-eastern boundary, although sharing the same symbology with the opposite side of the neighbourhood, is marked with both black and white dots. The density of points marking clear boundaries is higher on the correct segments, but some fuzzy areas are incorrectly assigned to them as well.

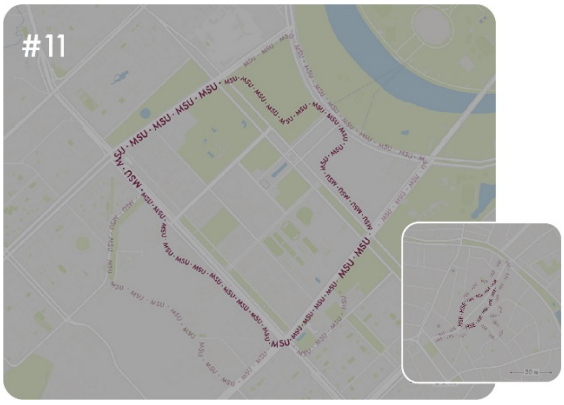
The markings of the HSE and TU Bauman maps are incomplete, but cannot be judged as incorrect.



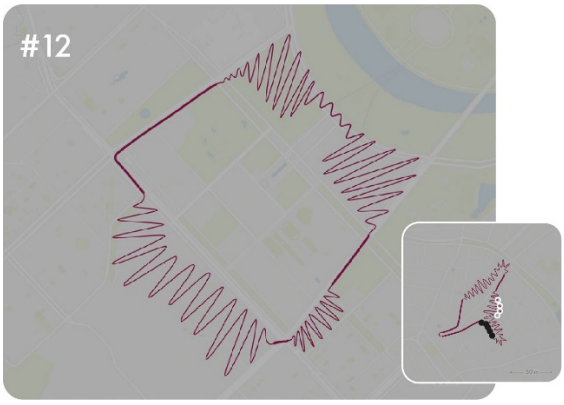
The varying size circles technique demonstrates rather promising results. A rare case, when all the marked points (with an exception of a few random dots) are placed along the actual boundary and not inside the neighbourhood. Fuzzy boundaries are mostly identified correctly. The density of points showing hard boundaries is higher on the correct segments, although a smaller amount of them is placed along fuzzy boundaries, too. This could be fixed by spacing up smaller points in the fuzzy areas, as it mentioned in a participant's comment.



On the heatmap, a small number of points does not allow us to confidently judge their distribution, but the marked points indicate a pattern: the fuzzy areas are identified partially correctly (in the south-west, at least), while the north-eastern part is marked predominantly as a crisp boundary, which is rather questionable.



Unfortunately, no data is available on this map – it was either never drawn or rejected by users.



The map was successfully drawn only one time, the user identified the boundaries just partially, but the placing is correct.

A user noted that "*the map triggers anxiety, although the intention was probably to show the vagueness of these boundaries".*

Analysing the results of this task allows us to objectively estimate how successfully different visualisation techniques provide information about boundary characteristics. In addition, the participants were also asked to evaluate the difficulty of performing the task by choosing from the options: "very easy, everything is obvious", "quite easy", "ok, but it took some thinking", "very difficult, nothing is clear". The chart below presents how the respondents judged the difficulty of the task. Only the records with a completed task and a chosen difficulty level were included into the distribution.

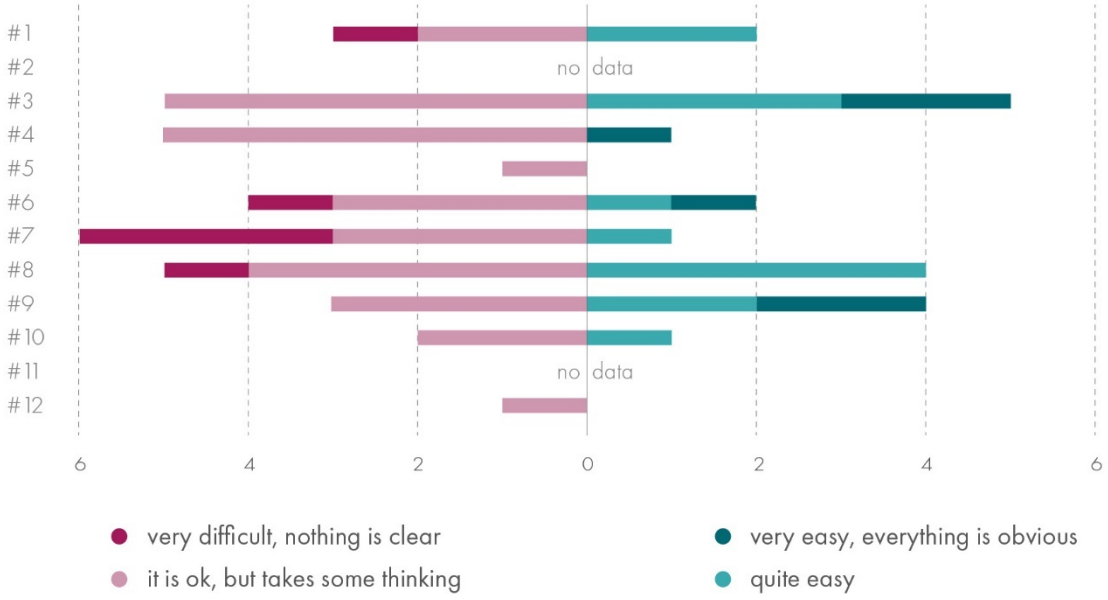
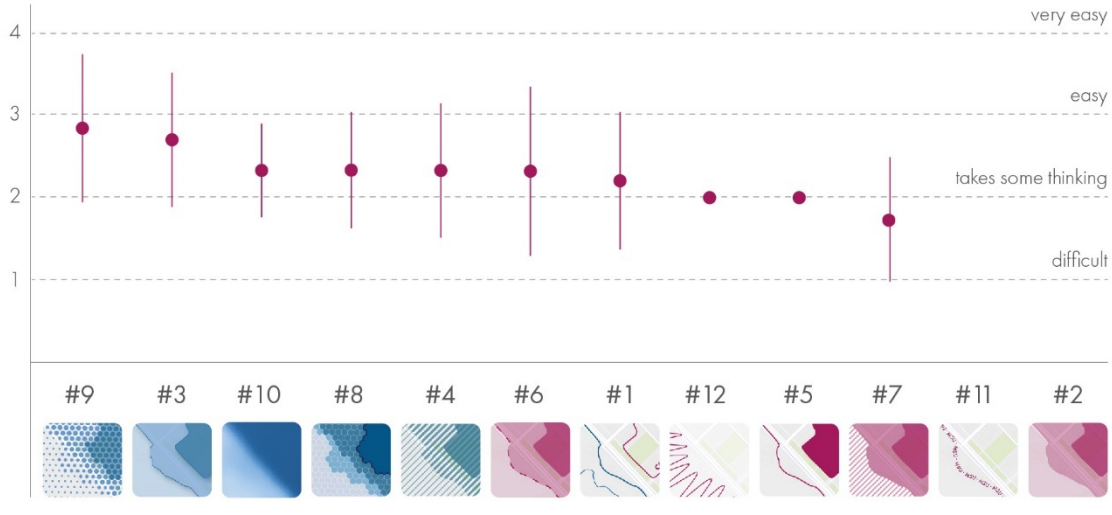


Fig. 5.6. Survey respondents' perception of the difficulty of performing the fuzzy and crisp boundaries identification task

Most of the answers (53%) tend to characterise the task as moderately difficult – "it is ok, but it takes some thinking". The maps #1, #6, #7 and #8 have received at least one "very difficult" mark. The maps #3, #4, #9 and, again, #6 were voted to be obvious (although, as noted above, all of them, except the map #9, showed rather controversial results). Mean values and standard deviations were also calculated for the ten maps whose data is available.



	#9	#3	#10	#8	#4	#6	#1	#12	#5	#7	#11	#2
μ	2,86	2,70	2,33	2,33	2,33	2,33	2,20	2,00	2,00	1,71	n/a	n/a
σ	0,90	0,82	0,58	0,71	0,82	1,03	0,84	-	-	0,76	n/a	n/a

The highest mean value (2,89) applies to the map #9 – on average across the sample, this visualisation technique is the easiest to understand. But, the standard deviation is equal to 0,9, which means that the assessment is not unanimous. The most difficult to work with is the map #7 with the mean value equals 1,71. The map #6 demonstrates the highest standard deviation, meaning that there is no consensus on its difficulty amongst users. Indeed, Fig. 5.6 demonstrates that this map received the most diverse feedback – all the rates from "very difficult" to "very easy".

5.1.5. Measuring appealingness the visualisation techniques

In the last section of the survey the participants were asked to express their subjective opinion and rank the visualisation techniques: choose three maps they like the most and one map which they find, on the contrary, the most unattractive. The response rate to this question was high enough to compare preferences of the respondents from MSU and HSE. The charts representing their answers are presented below.

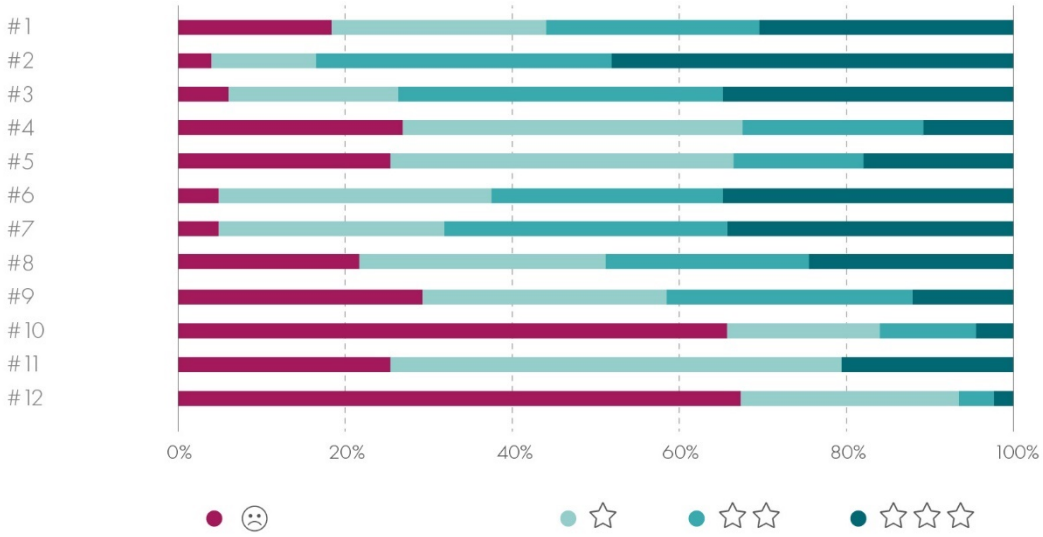


Fig. 5.8. Survey respondents' perception on which visualisation technique they like and dislike the most (MSU neighbourhood)

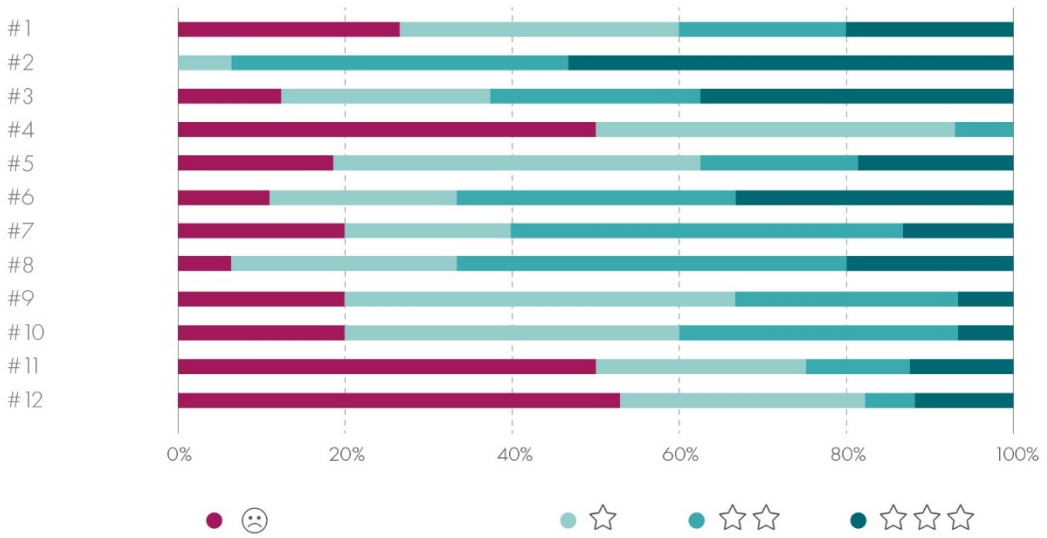


Fig. 5.9. Survey respondents' perception on which visualisation technique they like and dislike the most (HSE neighbourhood)

The patterns on the both charts are generally similar: the maps #2, #3, #6, #7 and #8 seem to be the most appealing for the users, but they tend to negatively evaluate the map #12 in both populations. Noticeable difference regards the map #10, which is particularly hated by the MSU respondents, and the maps #4 and #11 which did not find supporters among the respondents from the HSE.

To identify the maps favoured by all the respondents, the mean values and standard deviations were calculated. The "stars" and "smileys" were arbitrarily assigned with factors of "1", "2" and "3" for positive marks, respectively, and "-3" for negative marks in order to calculate the statistical indicators. According to the Fig. 5.10, users find map #2 the most appealing (with a mean grade 2,14); the standard deviation is also relatively low – 1,33 – which allows us to conclude that this result somehow reflects common perception. The second most popular map is a variation of the first: it employs the same visualisation technique supplemented with solid and dashed lines. With addition of the third most popular choice, 3D layers technique, the most popular maps are also the simplest: basically, they only represent three areas of the same colour yet varying transparency. Although, the absolute outsider is the map #12: despite the fact that the users understand the zigzag line representing fuzziness, they also noted that the technique evokes stress and is not suited for the purpose. The heatmap, #10, is the second least popular choice. The standard deviation values increase towards the end of the list, which means that less popular choices are not so consensual.

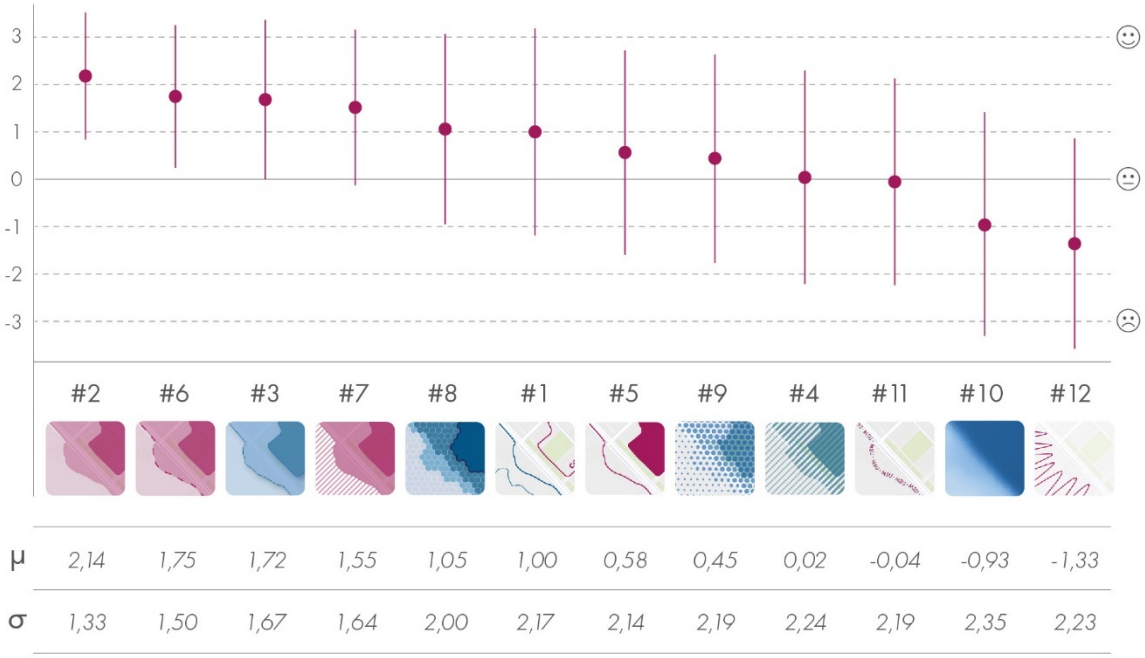
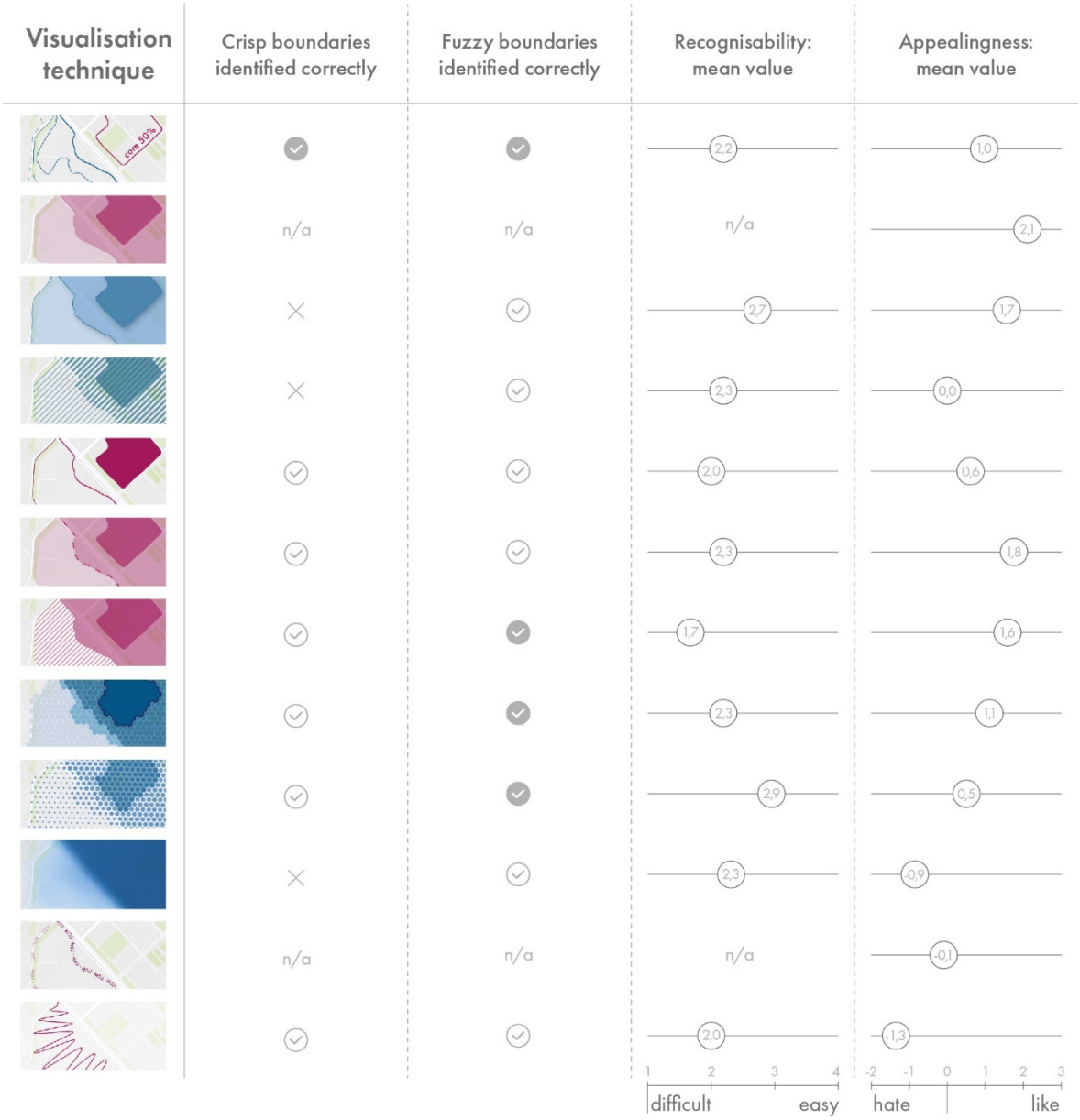


Fig. 5.10. The mean and standard deviation of the survey responses regarding the appealingness of the maps they were presented with

The table 5.2 is wrapping up the outcome of the evaluation survey. Most of the techniques allowed to identify fuzzy and crisp boundaries at least partly. One can notice that fuzzy boundaries were more often correctly identified than crisp boundaries. Since it was chosen to show the neighbourhoods not as solid polygons but as spatial objects with an inner structure, the boundaries of these internal parts were often taken for crisp boundaries of a neighbourhood itself.

Table 5.2. Performance of the tested visualisation techniques



Another observation concerns the identification features of fuzzy boundaries. It was often the case when only one fuzzy area (out of two or three) within a neighbourhood is identified correctly, although they all bear the same symbology. People notice the shape of the boundary prior to its symbology: a rounded wandering line is more likely to be identified as a fuzzy boundary than a straight line.

According to comments left by the participants and the results of ranking maps according to their appealingness, what users want is simplicity. Also, the maps overloaded with details demonstrated worse performance in comparison to simpler techniques and often were confusing.

The characteristic affecting the users' experience and the map's effectiveness is the ability to see the background. It was mentioned repeatedly in the comments section that the users would prefer if visualisation techniques allowed them to see it: *"It's very inconvenient when you can't see the map behind the markings. Or you can just barely see it and your brain is trying*

to figure it out", "The map I marked with an angry smiley – it doesn't show the basemap at all, without a street network it's harder to navigate within the area", etc.

There is no correlation between the difficulty experienced when reading the map and its appealingness. What could be expected, for instance, a high level of appreciation for the maps which are easy to work with, was not observed.

5.2. Discussion

Firstly, we need to acknowledge that the survey results were strongly influenced by its uneven population: the overwhelming majority were MSU alumni, students and employees, a smaller number were students and professors from HSE, and almost no result from the TU Bauman. By a certain degree, it even corresponds to the "insideness-outsideness" dichotomy which had been mentioned, in a slightly different context though, in the second chapter. The survey was quickly distributed among MSU students and alumni and less effectively – in the HSE community, but both had found the respondents predominantly within the author's private and professional network. It illustrated nicely how strong the connections are within a certain social group related to a place (a university, in this case) and how unobvious it is how to approach another community while being an outsider to it.

Another remark is related to the way the survey was designed. It was intentionally short and informal in order to possibly attract more participants and try to make them reflect on their perception of the neighbourhood in a casual (for the participants, at least) way. This gives some interesting insight content-wise, but makes it harder to analyse the results qualitatively: most of the gathered information – both verbal and graphical – needs an interpretation which is hard to be formalised.

By testing both visualisation techniques and geometrical accuracy of the neighbourhoods, the survey highlighted several steps where changing of methodology could lead to rather different outcomes. A cartographer should decide not only on the means of visualisation, but also on the principle how the neighbourhood (and, possibly, its parts) are to be delineated. In the chosen methodology based on calculating the percentages of people who claim each part of an area their neighbourhood, shifting a threshold results in noticeable change in a neighbourhood's shape. For instance, arbitrarily chosen 25% and 50% threshold identifying respectively sphere and domain parts proved to be justified since most of the respondents recognised their neighbourhood boundaries in the resulting maps. Although, it is trickier with identifying the core parts: one cannot rely merely on the overlapping polygons calculation, but also consider comments, textual descriptions and mentions of places carrying a certain meaning for the locals as focal points of their neighbourhood activity.

A terminological problem reveals itself with identifying crisp and fuzzy boundaries: it is easily understood by users when there is a long smooth transition from a core to a sphere (a typical case of a fuzzy boundary), or the contour lines of domain and sphere run along close to each other forming up a clear boundary with no transition zone. But once we have a boundary of a sphere part having a distinctive geometrical shape – like the one in the north-eastern part of the MSU neighbourhood – it causes confusion. It is not absolutely fuzzy since we can establish, more or less, its location; but the "expressiveness" of the neighbourhood is

quite low in this part so it is not crisp either. It is not absolutely clear how to handle these cases, but for sure the fuzziness in such cases should be more pronounced.

The crispest boundaries run along the old well-established borders of campuses where they are duplicated by physical or natural barriers (roads or rivers). They are also easily recognised by participants – for instance, the north-western boundary of the MSU neighbourhood is correctly identified on all of the maps.

Fuzzy boundaries are more successfully identified in comparison to the crisp. Although this might be a confusion brought by the three-parts structure – the boundaries of the domain are often taken for the boundaries of a neighbourhood. Oddly enough, depicting the crisp segments with a separate symbol does not help much: on the contrary, such techniques appear to be overwhelming and overloaded with unnecessary details. Ideally, when the difference is visible through varying transparencies/densities, they are apparently perceived subconsciously – the users see and comprehend the difference themselves, instead of being presented with the information processed and highlighted for them. Also, as noted above, not only symbology, but also the geometry of a boundary contributes to its identification – straight boundaries are less often recognised as fuzzy, even though they are carrying the same symbology with easily identified curved lines.

In all the three neighbourhoods, the main (and/or historical) buildings with almost no attached surrounding area were recognised as the core parts. This might seem like a trivial finding, but the comments often mentioned open spaces outside or street segments as the candidates to be the centre, but the evaluation results are quite certain. Unfortunately, for the TU Bauman this finding is based merely on the first survey results and had not been tested.

According to the participants' preferences and comments, the most important characteristics for the users are clarity, simplicity (a minimum number of colour/texture steps) and, last but certainly not least, the ability to see the basemap. The latter was particularly often mentioned as a positive feature of the preferred visualisation and a common complaint about some of the unpopular techniques. The mixed methods also did not gain much popularity: overloading maps with additional details brings more confusion than new information. For instance, the very basic contour lines method turned out to be both popular and effective in providing the boundaries information.

Is it possible to predict how successfully the technique will convey fuzziness? According to table N, which formalises the features of all the tested techniques, the potential winner was a contour lines method (it differentiates clearly the core, domain and sphere parts; allows to see the background and is flexible with changing the number of internal steps or overlapping with other neighbourhoods). This agrees with the findings of the evaluation survey, where the crisp and fuzzy segments were identified quite correctly on this map. Although, the technique is not amongst the most popular maps (see table 5.2). Also, it is not the easiest to work with, according to table 5.2. The technique #5 looked also quite promising in the visualisation techniques table. Unfortunately, there is not enough data to confirm or deny that assumption. The next candidates – the techniques #4 and #9, showed different results: the varying circles technique performed rather well and was also evaluated as the easiest technique to work with, while the hatching style appeared to be quite confusing. With a limited set of data, it could be also concluded with a certain degree of confidence that the

contour lines and the circles of varying size techniques perform decently and can be employed in the fuzzy areas' representation. The other methods, such as #2, #4, #5, and #8 have their right to exist, but should be studied more closely for particular applications.

6. Conclusion

The undertaken study lies at the intersection of human geography, cartographic data visualisation and place theory. It aims to contribute to existing neighbourhood studies and to broaden the scope of research into cartographic representations of university neighbourhoods, their boundaries and internal structure. Neighbourhood is treated as a platial feature – it completely depends on feelings, associations and identity connecting people to certain places. To clarify the geography of the neighbourhoods as a step prior to the cartographic techniques' generation, three key aspects of neighbourhoods as places were investigated during the survey: location, locale, and sense of place.

RO1 seeks to generate cartographic means to depict 1) boundaries and 2) internal structure of university neighbourhoods. The data gathered during the prestudy survey allowed to detect the boundaries efficiently: the methodology was based on calculating the percentages of people who claim each part of an area their neighbourhood and setting a threshold to delineate domain and sphere parts. The method can be justified since most of the respondents recognised their neighbourhood boundaries in the resulting maps. Although, the same methodology does not work flawlessly for core parts detection and needs some adjustment; the additional information regarding important amenities in the area can contribute to identifying the core parts of neighbourhoods.

In order to reach RO2, evaluating different cartographic techniques and comparing the results helps to understand how the techniques deal with conveying geography and sense of place of university neighbourhoods in comparison to each other. Despite strong differences in that performance, it is hardly possible to name one undoubtedly proper technique. The answers showed that the most important characteristics of a successful visualisation technique are the ability to see a basemap, simplicity and clarity. The techniques possessing these characteristics can be employed to neighbourhood's visualisation and able to successfully convey both crisp and fuzzy boundaries.

The evaluation survey also revealed that it is easier to identify fuzzy boundaries in comparison to the crisp boundaries. Possibly, the inclusion of sub-levels, such as distinction between domain and sphere parts, brought this confusion: the domain borders are often mistakenly taken for crisp boundaries of a neighbourhood itself. Also, the maps most appealing for the users are not necessarily the easiest to work with: the techniques which demonstrated the best result in crisp and fuzzy boundaries recognition had only average levels of appealingness in comparison to the other tested techniques.

Potential further research of neighbourhood boundaries visualisation may benefit from better targeting. Participation of people from different backgrounds can make the resulting maps more relevant and trustworthy. Also, the current study did not consider any demographic analysis, while potentially this may allow us to trace how the boundaries of a neighbourhood have been changing over time or is there any difference in perception of the

same area for the different groups of people. Apart from that, it is beneficial to know how the city dwellers perceive the urban area and a proper technique for its visualisation can help the researchers working in the field better bring their findings to a broader audience.

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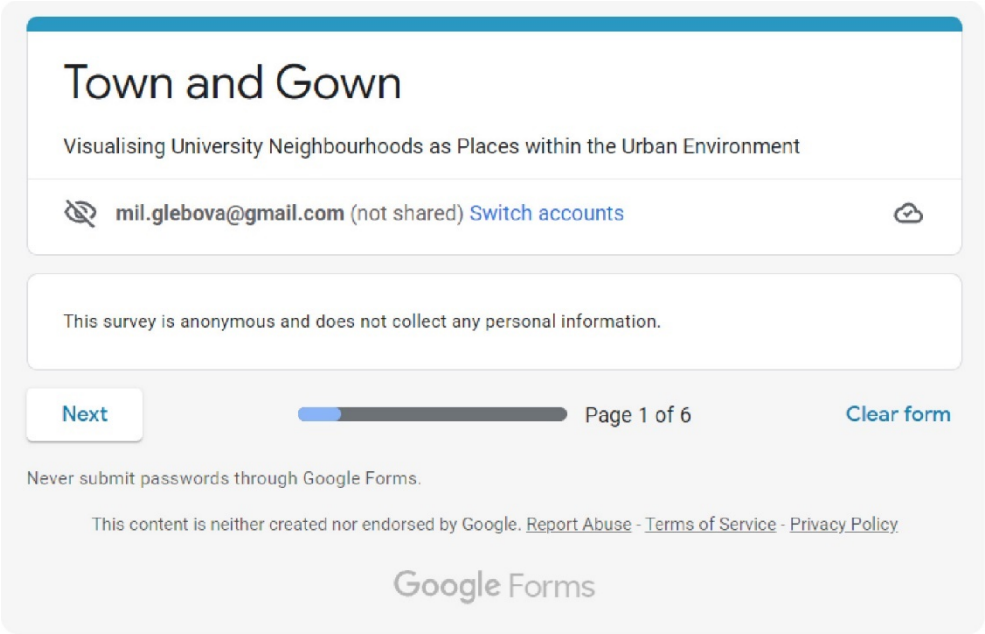
Appendix 1

Online Prestudy Questionnaire Screenshots



Town and Gown

mil.glebova@gmail.com (not shared) Switch accounts

Introduction

1. Who are you?

- ◯ Student
- ◯ Member of staff
- ◯ Other: _____

2. At which university do you work or study? (or did it in the pasr)

- ◯ Lomonosov MSU
- ◯ Higher School of Economics
- ◯ Bauman Technical University

3. How many years have you been working/studying there?

Your answer

Back Next Page 2 of 6 Clear form

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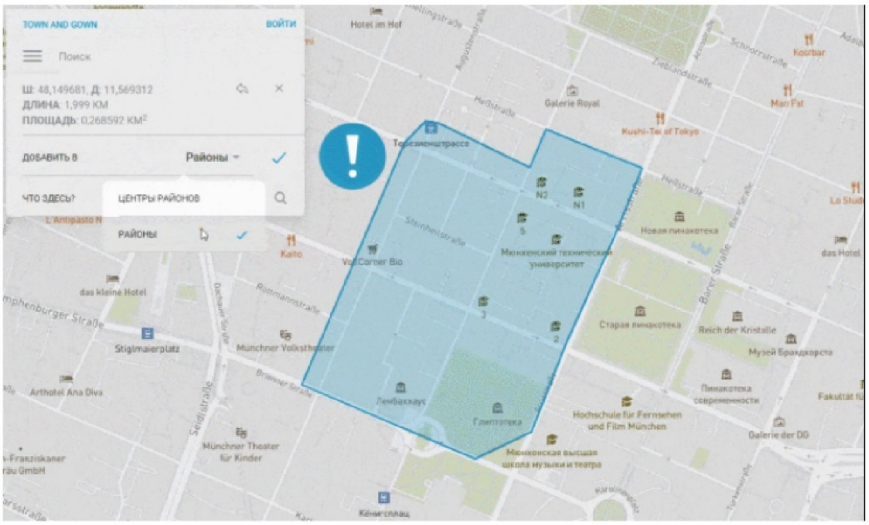
Town and Gown

mil.glebova@gmail.com (not shared) Switch accounts

The boundaries of a neighbourhood

4. Please draw the boundary of your university neighbourhood on the map: https://map.geosemantica.ru/home?puuid=5c9c9ff8-b8ab-41bc-8545-3bde76f4a18b&mode=map (! to start editing, long press the left mouse button)

There is no right or wrong answer; you just have to mark the part of the area you consider associated with your university (even if administratively it's not the case). For instance, I've got this image of the TUM neighbourhood: there's not just university buildings there, but also neighbouring streets full of student cafes, fast food places, groceries and print shops. The lawn on front of Glyptotek I also consider "my" TUM neighbourhood: always had a feeling, that most of the people spending time there are local students, not tourists. You neighbourhood can have any shape, even consist of several isolated parts – just make sure you've given them intuitively clear names on the lest side of the map interface.



Your answer

You can also add comments about the boundaries, local toponyms, relations to neighboring territories, etc. Please, use the field below the gif image.

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Town and Gown

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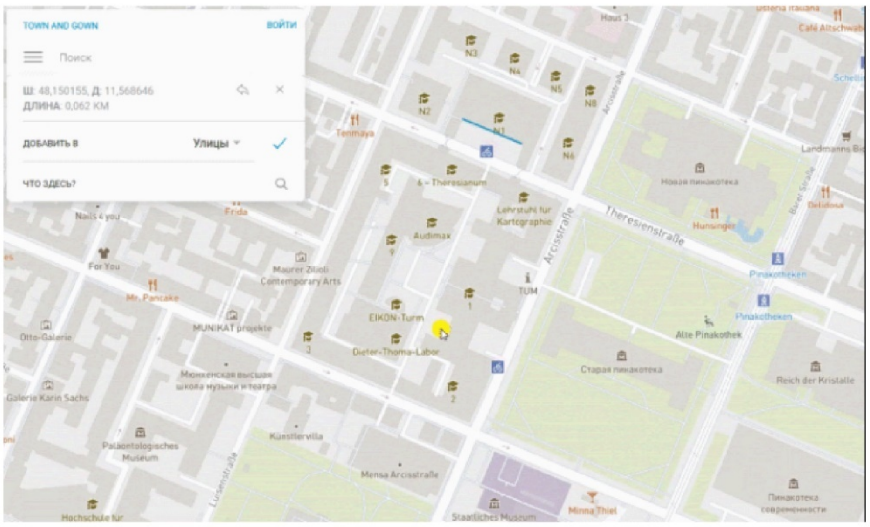
The centre of the neighbourhood

5. Which part of the neighbourhood you would call its centre? Please, mark on the map: https://map.geosemantica.ru/home?puuid=5c9c9ff8-b8ab-41bc-8545-3bde76f4a18b&mode=map (! to start editing, long press the left mouse button)

By "centre part" I don't mean geographical centre but the soul of the area, it's focus point – wherever it is in your opinion. For instance, in my TUM example I consider a cozy inner yard a core part; it's faced by the library, cafeteria, the picturesque clock tower, etc. The inner yard is always full of life, especially during the breaks when it gets crowded by the people from several buildings surrounding it.



Your answer

As in the previous question, you can use the field below the gif image to add additional comments.

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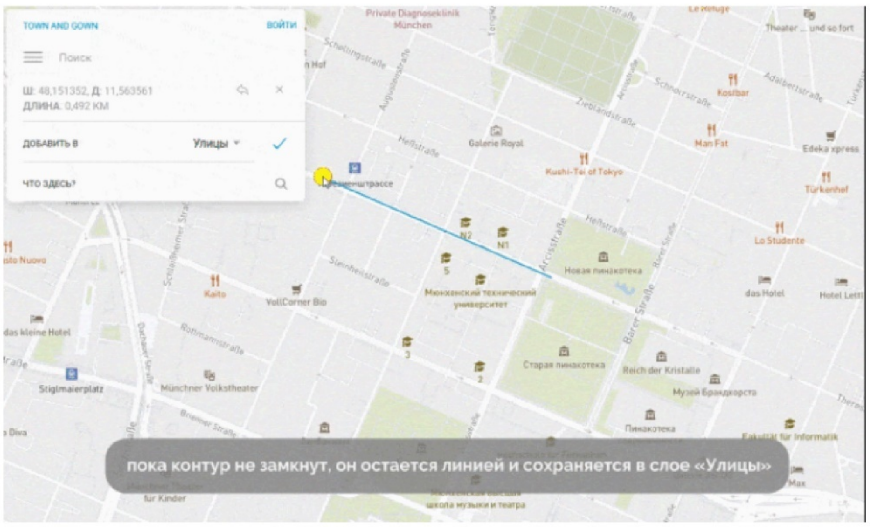
The "skeleton" on the neighbourhood

6. Which streets within the boundaries of your neighbourhood you walk more often? Please, mark on the map: https://map.geosemantica.ru/home?puuid=5c9c9ff8-b8ab-41bc-8545-3bde76f4a18b&mode=map

Not the widest streets, but the most crowded, the ones you and other people from your neighbourhood use more often. In my example I marked Theresienstraße which leads to the subway station, Luisenstraße leading to popular among locals grocery store, and the walkway through the inner yard I described in the previous question.



Your answer

As in the previous question, you can use the field below the gif image to add additional comments.

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Additional information

7. How do you usually get to the university? (You can name a subway station, bus stop or/and briefly explain your walking or cycling route)

Your answer

8. Where do you usually spend time studying?

- [ ] At home
- [ ] In cafes close to the campus
- [ ] In the library
- [ ] In the university buildings
- [ ] Other:

9. Where do you usually hang out with your groupmates/colleagues?

- [ ] On the campus
- [ ] In cafes close to the university
- [ ] Outside the campus
- [ ] Other:

10. Which cafes/bars/shops in the university area do you visit more often?

Your answer

11. Which part of the university area you feel the most comfortable in?

Your answer

12. How do you usually call the university area (or parts of it) while setting up a meeting with your peers there?

Your answer

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Appendix 2

Qualitative answers to the prestudy survey

Translated from Russian

The comments given to particular areas outlined by the users on the map

The boundaries of a neighbourhood

MSU

- *The eastern boundary (between Kosygin St. and Universitetsky Ave.) is unclear as the area is mostly fenced and inaccessible.*
- *In the northwest, the boundary may be as far as St. and Leninsky Prospekt metro station.*
- *University grounds, fountains, the Auchan, the observation point on the Sparrow Hills.*
- *The buildings to the south of Lomonosov Avenue are too ugly to remember. The area on Mokhovaya St. was rarely visited.*
- *In general, the MSU campus area coincides with the area "inhabited" by students. Of the uncharacteristic places that have fallen within the boundaries of the area, I would like to mention the Great Lawn.*
- *It's small but cosy. I don't study here, but I have visited the place.*
- *University buildings themselves.*
- *The south-western boundary is unclear, either on wasteland or at the beginning of housing estates. But the Capitoly shopping mall is definitely included [to the neighbourhood].*
- *The main centre is the Faculty of Economics + added arena and PE field + MB + Auchan (food and shopping) + circus (parking there).*
- *Parks, teh football fields, the botanic gardens, shopping malls.*

HSE

- *The "historical" HSE cluster includes the buildings M20, M11, M13, and also the "Armyansky" building (in the Armyansky lane).*
- *The square closest to the Lubyanka metro station is where students often sit. The rest of the boundaries are shaped based on points of attraction – to the main academic buildings and institutions visited.*
- *In fact, the "university" vernacular could also include Pokrovka and the building on Basmannaya, but these are significantly distanced from the main building.*
- *The university area is not just a street, but also the venues on it, so it is as if the border runs around them rather than along Myasnitskaya itself.*

TU Bauman

- *Main building, ULC, faculty buildings, dormitories, underground and connecting spaces.*

The core of a neighbourhood

MSU

- *I would also highlight the islet before the entrance to sector A.*
- *There is a particular buzz of life on the steps of the Main Building. I didn't mention the Main Building and the buildings themselves, because that's more of an inside story.*
- *Smoking places at the exits of MB (at the both sides) – the very centre.*
- *The "Puck".*
- *I think the centre is a non-alternative for MSU.*
- *The square with the Lomonosov monument is usually more crowded.*
- *Main faculties and a recognisable main building.*
- *The focal point of all: the steps in front of the entrance to Khokhlova St. (the so-called club entrance) and the "puck" with refreshments inside, just after the entrance.*
- *Between the Faculty of Economics and the Law school – everyone goes out [there] for a smoke.*

HSE

- *Includes the former HSE building and 2 new buildings + the iconic hangout facilities around it.*
- *Undoubtedly the core includes buildings M20, M11 and M13 with all the coffee shops in between where meetings are held.*
- *The new HSE building is the core of the cluster. This building is called both "Pokrovka" (although Pokrovka St. itself is a bit far off).*
- *Here is the pavement triangle at the crossroads where everyone meets before the start of classes and where they go out during breaks, including for a smoke.*
- *The building where I study, that's why it's the centre.*
- *On Myasnitskaya St., where everyone is always eating lunch, chatting, sitting and walking around*
- *Starbucks – always full of HSE students*

TU Bauman

- *Even the air there seems somehow special to me. When I go there, I walk and smile all the time. There are too many memories associated with this place.*

Appendix 3

Online Evaluation Questionnaire Screenshots

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oFb - der onlineFragebogen

Town and Gown

Visualising University Neighbourhoods as Places within the Urban Environment

This is the second survey conducted as part of the Cartography Ms Programme master's thesis. It is designed to test different ways of visualising neighbourhoods with crisp and fuzzy boundaries using the examples of university districts of Moscow State University (Sparrow Hills campus), Higher School of Economics (Myasnitskaya cluster), and Bauman Moscow State Technical University. We are talking about neighbourhoods as they are considered 'their own' by their inhabitants - mostly students and staff - rather than official campus boundaries.

There are only 7 questions inside - it won't take longer than 5 minutes to answer them.

Some questions have a field to leave comments - this is optional, but if you have the time/willingness to explain your answers, it will help me a lot with the analysis of the results.

This survey is anonymous and does not collect any personal information.

Next

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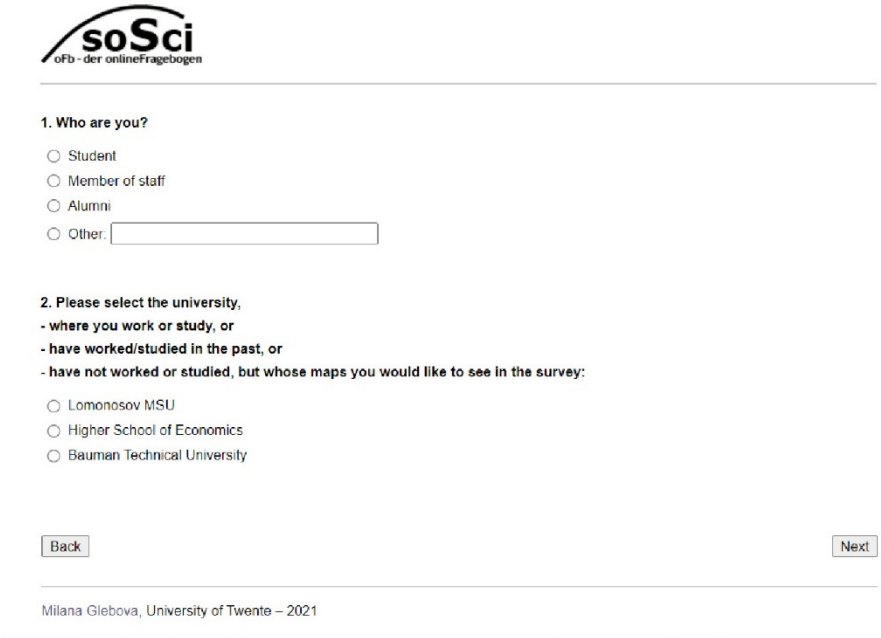

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1. Who are you?

- ○ Student
- ○ Member of staff
- ○ Alumni
- ○ Other:

2. Please select the university,
- where you work or study, or
- have worked/studied in the past, or
- have not worked or studied, but whose maps you would like to see in the survey:

- ○ Lomonosov MSU
- ○ Higher School of Economics
- ○ Bauman Technical University

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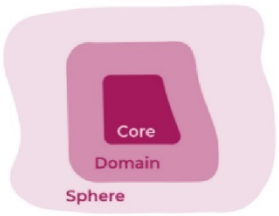
In order to construct the neighbourhood maps, I used the data from the previous survey. By overlaying the individual polygons drawn by the participants, the following areas were identified:

Core: area designated as the centre of the district by more than a half of the participants (in a separate question)

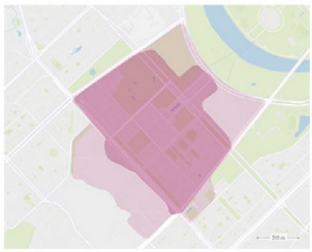
Domain: an area that more than 50% of the respondents consider their neighbourhood

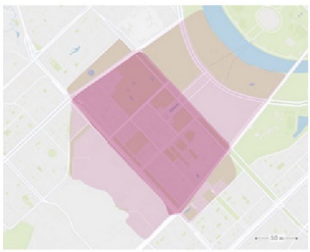
Sphere: an area outlined as thier neighbourhood by 25-49% of the respondents

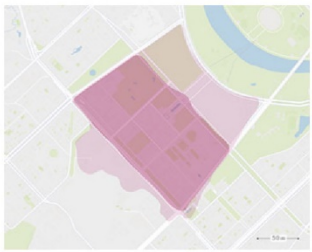


3. Now we need to find out how plausible the results from this method are. Please choose the map on which the boundaries of the neighbourhood are most similar to your idea of them.

This question is not a test of your knowledge of the geography of an area, but of your methodology for delineating neighbourhoods. If you are not a student, graduate or university employee and have a poor understanding of the area, just skip this question and move on to the next page.







None of these maps, because

4. Now look at the core. Choose the map that most closely matches your idea of the neighbourhood's core location and shape.

None of these maps, because

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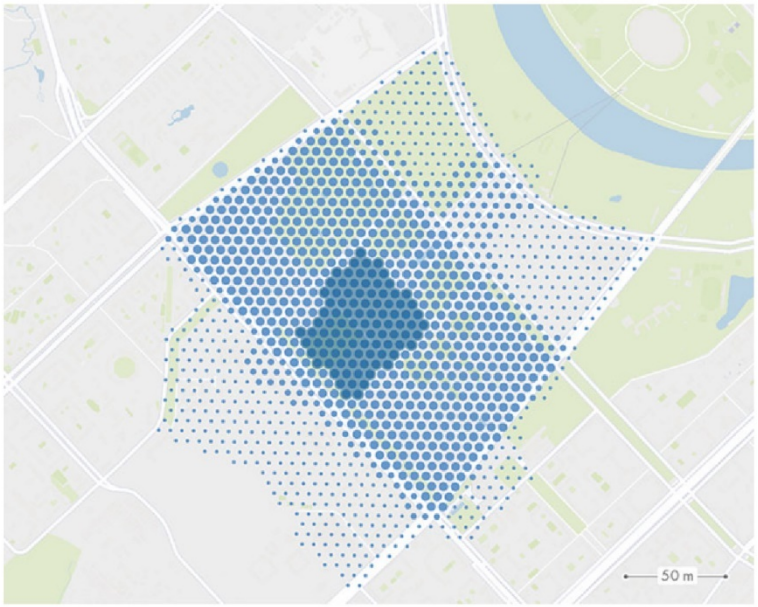
5. There is one of the visualisations of the neighbourhood boundaries in front of you. According to this map, which boundaries of the neighbourhood are the clearest? (The neighbourhood, not the individual parts – the body or the core.) And the most fuzzy? Put points along these areas, using the legend (below).

If you have mistakenly marked points in the wrong place, you can move them (with left mouse button) or delete them (with right mouse button). On a smartphone, you can delete points with a long tap (then it's better to zoom in closer to the map).



- (●) Crisp boundaries
- ( ) Fuzzy boundaries

6. Please evaluate how easy it was to identify clear and fuzzy boundaries using this map: Q301

Difficult, absolutely unclear	All right, but it took some thinking	Rather easy	Very easy, everything is obvious
○	○	○	○

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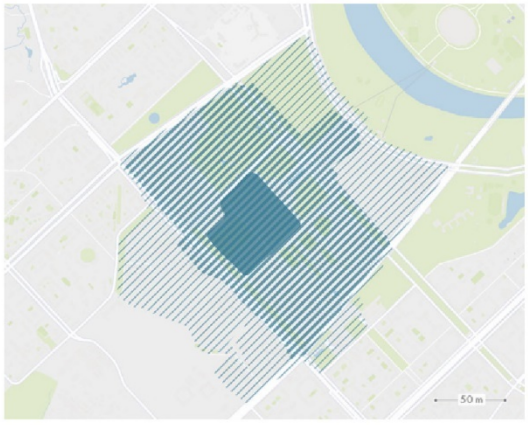
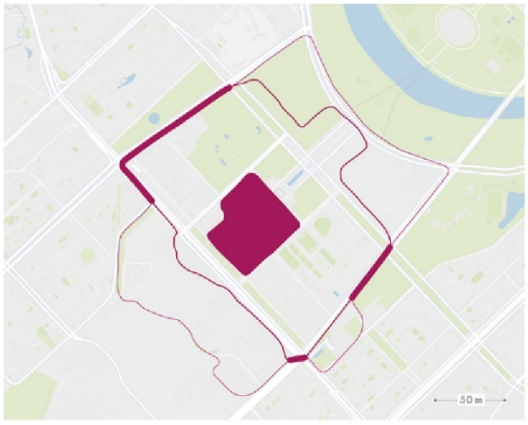
7. A question of purely subjective preference – which map do you like the most visually?

Rank the three favourite maps with the corresponding number of stars, and mark the one that you particularly dislike with an angry smiley.

(If you really want to, you can mark either more or fewer favourites and underdogs.)



[all the twelve visualisations]



Here you can leave comments on your choices: which elements succeeded, which annoyed you, or what these visualisations lack:

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Thank you very much for your participation!

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Appendix 4

Qualitative answers to the evaluation survey

Translated from Russian

Neighbourhood recognition

No map represents the correct outline of the neighbourhood, because…

MSU

- *Domain does not include the so-called "new territory" (behind Lomonosov Ave); sphere either does not include the "new territory" or does include (at least in fragments) the Dominion housing estate near the University underground station.*
- *My understanding of the core and centre is not the same as that suggested by the maps (it is more expansive).*
- *MSU has more than one "campus".*
- *"My" neighbourhood by the MB has been extended to the SHB (former Balaton shop and cinema Lithuania)*
- *The grounds of the Student House Branch (SHB) on Lomonosov Ave. have been overlooked.*
- *None of them have a "core" area according to the legend, which is quite odd.*

No map represents the correct core of the neighbourhood, because

MSU

- *The largest map in terms of coverage is closest to the notion of the "core", but we need to add a part of the alleyway near the Department of Biology there as well.*
- *The large cluster of Biology Department buildings is not part of the core. For me, however, it is.*
- *Doesn't include the Economics Department, The First GUM, the Law Department – there are a lot of students here, there is a lot of foot traffic along Vernadsky Ave.*
- *The Biology Department and the new territory are missing.*

The appealingness of the maps: which elements succeeded, which annoyed you, or what these visualisations lack:

MSU

- *Three shades are enough to illustrate an object, everything else is redundant.*

- *It's very inconvenient when you can't see the map behind the markings. Or you can hardly see it and your brain is trying to figure it out.*
- *The map with the percentages is the most informative, which is positive. The map I marked with an angry smiley doesn't show the basemap at all, and without a grid of streets "inside" the area is difficult to navigate. The maps with the dots and hatching, in my opinion, are visually aggressive (maybe a little lower contrast of colours would help?..), against them the map with the "honeycomb cells" wins, the only drawback – the basemap is also barely visible.*
- *Interesting solution with the MSU edging. Most liked the gradient ways of depicting it, they are smooth and don't pressurise the perception. The dot-circle map is not for people with trypophobia :) The blue map with blur very strongly and unpleasantly impacts the vision, the focus of the eye :(Hexagons – not bad, but as if we overload the map, do not give additional information. It's not clear why on the second map the line is dotted in one place and solid in the other? The heartbeat map is disturbing, although the intention was probably to show the vagueness of these boundaries.*
- *The legend is lacking.*
- *It may make sense to try the option with increasingly sparse dots (mottling) on the least clear boundaries.*
- *Perception was disturbed by dashed fillings or boundaries in the form of lines of different thickness, where the image had to be enlarged quite strongly to separate the core or boundary area.*
- *Street names are missing.*
- *Where the "clarity" of boundaries needed to be assessed, the basemap is poorly visible through the fill, which is disturbing.*

HSE

- *[They] lacked a legend... [I] marked the maps where there are no problems with navigation and where it is more or less clear what is meant. The hexagons completely hide the basemap. The dots are funky, but unlikely to be well understood. The hatching definitely doesn't look good, the raster doesn't look good either. But the most confusing is the ruffled porcupine I marked with a frowney.*
- *In my opinion, it is desirable for the map to have 1) a division into zones (core, body, zone of influence), 2) a different representation of strict and permeable boundaries, 3) street visibility under the neighbourhood symbology layer.*
- *Depends on the prominence of the contours of the neighbourhood's boundaries. For example, on maps 7 and 12. Yes, it is unconventional, but the area is hard to see. Map 3 is directly very unfortunate: it is not clear where the core is, nor where the domain is, and it is very difficult to read because of the technique (just heartbeats of some kind). On the whole, those maps which show a clear division of the "zones" and the boundaries of the whole area (2, 9, 11) turned out well. [The participant uses the numbers by which the maps appeared on his/her page without knowing that the order is shuffled; although it is possible to take a guess which map is meant most of the time]*