Spatial social networks for the humanities: A visualization and analytical model

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RESEARCH ARTICLE

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Spatial social networks for the humanities: A visualization and analytical model

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Abstract

In this article, we propose a model to identify and visualize family structures across a database of over 70,000 Jewish individuals living in Budapest in 1945 in the immediate aftermath of the Holocaust. Once family structures are identified, their distribution can be mapped in a historical GIS, a type of GIS expressly designed to study past geographies. Our work contributes to nascent research in spatial social networks in several ways, most importantly with its emphasis on uncertainty, the focus on edges as well as nodes, and the development of a visualization that allows for the prompt and immediate comparison of family structures regardless of their number. We also see our research contributing to the discourse on platial GIS, or the GIS of place.

1 | INTRODUCTION

In this article, we propose a model to identify the spatial and structural characteristics of a specific type of social networks: the family. The model is the third (Giordano & Cole, 2018, 2019)—and the most fully realized—in a series we have developed in the last four years as part of our work on the topic of platial GIS, or the GIS of place. The model is both a visualization of a spatial social network and an analytical tool and it is also replicable and adaptable to projects in which the dataset Dunder study includes temporal and spatial information as well as demographic data. The case study we discuss in this article concerns the immediate post-Holocaust period in Budapest: in the summer of 1945, the Hungarian Section of the World Jewish Congress—American Joint Distribution Committee and the Jewish Agency for Palestine Statistical and Search Department (World Jewish Congress in brief) commissioned a door-to-door survey to determine where Jewish survivors were living in the city, which at the time was the largest single urban concentration of Jews in post-war Europe. The information collected in the survey

was published in the volume *Counted Remnant* (World Jewish Congress, 1946), which was disseminated globally to enable family members to find out if their relatives were still alive, and if so, where they could be found. The volume lists the names of over 70,000 individuals, including their first and last name, place of birth, mother's name, maiden name (if applicable), and address of residence. Over the course of two and a half years, we digitized and mapped in a historical GIS the address of residence of the over 70,000 individuals in *Counted Remnant*. The map in Figure 1 shows the spatial distribution of survivors in the city at the resolution of the over 10,000 individual addresses in the database. The starting point to georeference these addresses was the historical GIS of the Holocaust in Budapest (Cole & Giordano, 2014), which we supplemented with geolocating tools from Esri, manual checks in Google Maps, and internet searches on the urban history of Budapest. In the end, we were able to find all addresses on the list. Demographically, 61.8% of the survivors were females and 38.8% were males; this was also a relatively old population, with approximately 54% of the individuals between the ages of 40 and 69. From the list, we were able to reconstruct the family structures of survivors of the Holocaust in Budapest. What we are particularly interested here is how a visualization we developed to reveal family relationships may reveal post-genocide social-spatial networks that were created in and through urban space in the immediate aftermath of the war.

2 | BACKGROUND

While a full treatment of the role of place in geography and its various theorizations is beyond the scope of this article (see Adams, 2017 for a review), we see place as a dynamic entity, a product of social processes, individually

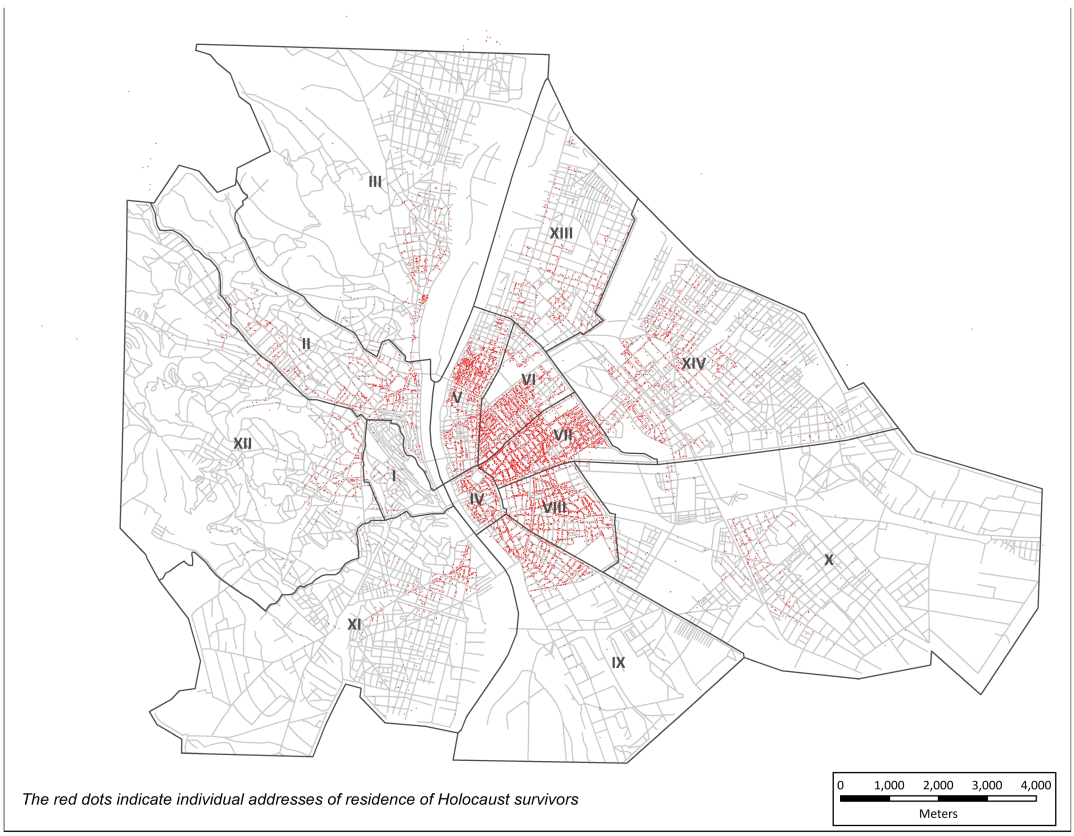

FIGURE 1 Addresses of residence of Budapest's Holocaust survivors

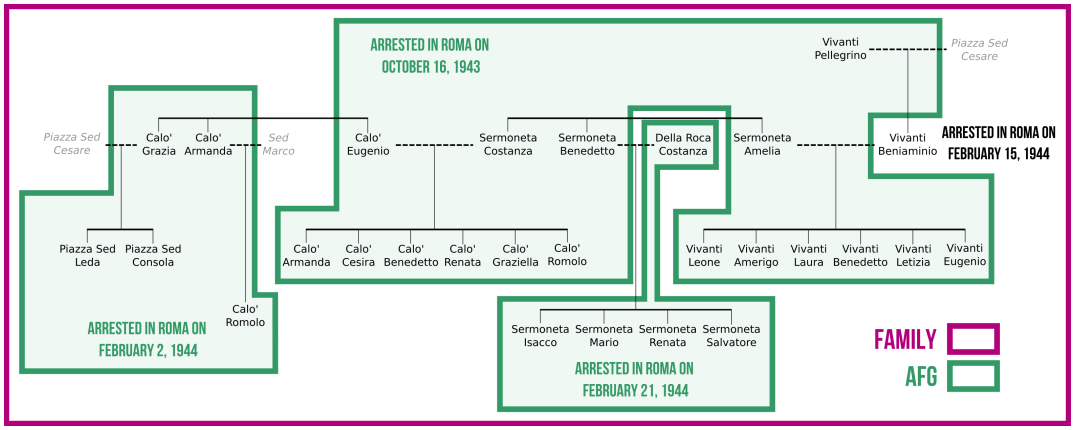

FIGURE 2 Example of one family and its related AFGs (Arrested Family Groups). In light grey are individuals for which no entry exists in the database

experienced, and constituted by the triad of location, locale, and sense of place, as proposed by Agnew and Duncan (1989). This definition incorporates the idea of abstract space as it is understood in GIScience (location); the social, cultural, political, economic, and material dimensions of place (locale); and the behavioral and emotional component of place (sense of place, as theorized by Tuan, 1977). These three concepts are at the core of the idea of GIS of place, or platial GIS (Goodchild, 2015), and while the terminology may be novel, academic debates concerning the relationship between GIS and place are not new and date back at least to the discussion on "critical GIS" of the 1980s and 1990s (Curry, 1998; Egenhofer & Mark, 1995; Pickles, 1995; Scheider & Janowicz, 2014; Sheppard, 1995; Smith & Mark, 2001; Thatcher et al., 2016). More recently, the discourse about space, place, and GIScience and the use of qualitative methods—or, rather, mixed methods—have resurfaced in the context of the spatial humanities and the geohumanities, human geography, historical GIS, and qualitative GIS (Bodenhamer, Corrigan, & Harris, 2015; Cope & Elwood, 2015; Dear, Ketchum, Luria, & Richardson, 2011; Drucker, 2012; Giordano & Cole, 2018). Recent symposia on the topic (Giordano, Shaw, & Sinton, 2020; Westerholt, Mocnik, & Zipf, 2018) offer different perspectives and approaches to the theory and practice of a GIS of place. We can see a consensus developing around the centrality of location, locale, and—in lesser measure—sense of place to advance research on the GIS of place (Merschdorf & Blaschke, 2018; Purves & Derungs, 2015; Purves, Winter, & Kuhn, 2019; Shaw & Sui, 2020). As we discuss elsewhere (Giordano & Cole, 2018, 2019), in addition to being centered on this triad, a GIS of place is relational and topological. In his classic study of space and place, Yi-Fu Tuan observed that "home" is not necessarily anchored in place (Tuan, 1977): it can reside in a person or in a personal relationship, and in this sense place and social relations are inextricably intertwined and one cannot be studied without the other. The social is spatial and social relationships are explicitly spatialized, that is, they are inextricably and explicitly described as happening in and through space. In this article, we focus on families, for many perhaps the most fundamental type of personal relationship.

While the theoretical confines of a GIS of place are quite well defined, much less progress and consensus have been made and reached concerning how to actually build a GIS of place. We believe the toolbox for a GIS of place must include the ability of representing and analyzing qualitative spatial relationships as well as exploring narratives and other qualitative, textual materials (Giordano & Cole, 2018; Miranker & Giordano, 2020; Murieta-Flores, Donaldson, & Gregory, 2017). Tools, methods, and approaches developed to do this include qualitative spatial reasoning (QSR)—a language for formalizing and analyzing qualitative spatial relationships, with origins in computer science and GIScience—and corpus linguistics (CL) and natural language processing (NLP)—big data techniques that originate in linguistics and computer science. QSR, CL, and NLP have been used in digital humanities and spatial humanities projects (Bailey Kellog & Zhao, 2004; Cohn & Hazarika, 2001), including Holocaust Studies (Cole & Hahmann, 2019; Knowles, Jaskot, Cole, & Giordano, 2021). Taken together,

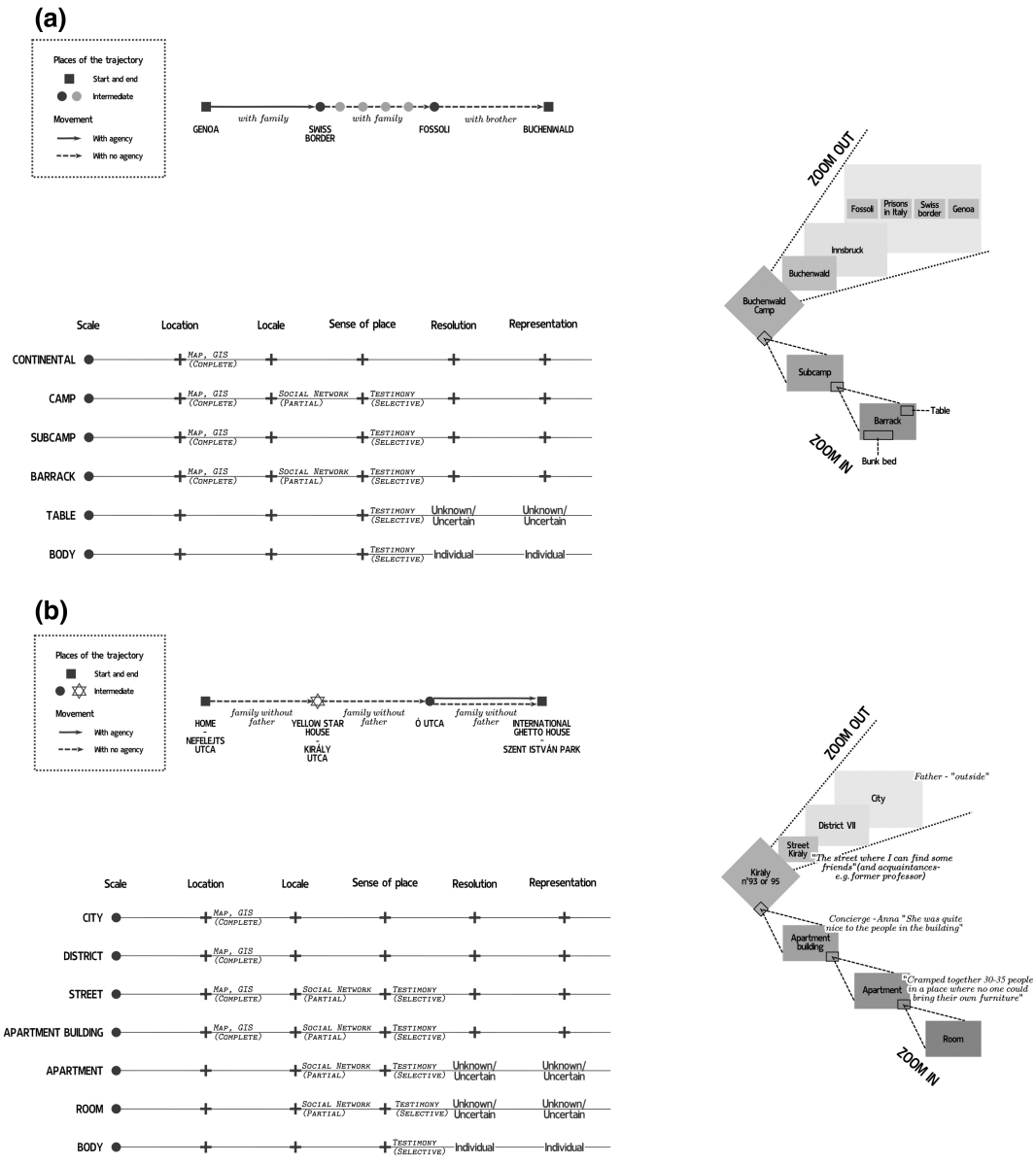

FIGURE 3 The spatio-temporal trajectories of Gilberto Salmoni and Magda Mezei

they provide a framework for searching for key terms or themes throughout multiple textual sources, narratives, and testimonies, highlighting and visualizing the presence of spatial relationships that are not necessarily mappable in Cartesian coordinate space and in a traditional GIS setting (Knowles, Cole, & Giordano, 2014; Miranker & Giordano, 2020; Pavlovskaya, 2018). In addition to QSR and CL, a third technique is posited to play a fundamental role in the future toolbox of the GIS of place: social networks analysis, or to be more specific, spatial social networks analysis, the focus of this article. Social networks are graph structures that consist of nodes and edges, in which nodes typically represent individual entities such as people or institutions (which in the case of social spatial networks can be spatialized), and edges represent interpersonal relationships, connections or ties (Andris, 2019). As a way of spatializing social networks—or, if one prefers, adding the social dimension to spatial networks—several authors have proposed methods to integrate social networks analysis

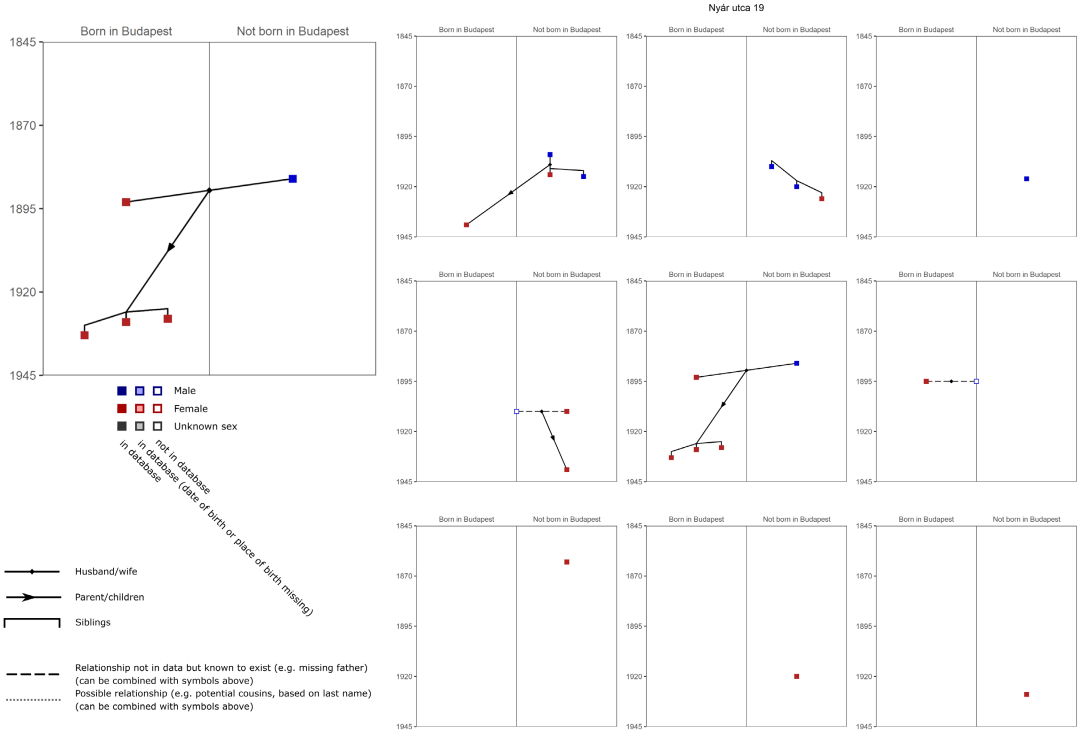

FIGURE 4 Place of residence of families in post-Holocaust Budapest

and GIS: see, for example, Andris (2016), especially the idea of anthrospace and ways to measure it, and, in the context of the transmission of disease, Emch et al. (2012). As it applies to Holocaust Studies, see Chronakis (2018) for Greece, and Giordano and Cole (2011) on the social and spatial networks of the Budapest Ghetto. A striking characteristic of the literature on spatial social networks is its strong interdisciplinary dimension. Spatial models for social networks have been proposed by researchers in a variety of fields, including Wong, Pattison, and Robins (2006), Barthélemy (2011), Johnson and Giles (2003), Scellato et al. (2011), Lee and Kwan (2011), Doytsher, Galon, and Kanza (2010), and Illenberger et al. (2013). Doreian and Conti (2012) argue for the consideration of context, both spatial and social, in the study of social networks, and offer examples of the effect of context using five empirical networks. In doing so, they show that context contributes to shaping the structure of networks and that a variety of network analytic tools can be used to reveal how networks are shaped, in part, by social and spatial contexts. Relevant to our research, Andris, Liu, and Ferreira (2018) discuss spatial social networks as social and interpersonal connections that are attached to spaces and places, proposing formal definitions of social flow data and, most interestingly, redefining social distance as the manifestation of social flows. Sarkar, Andris, Chapman, and Sengupta (2019) go one step beyond by introducing a set of new metrics for spatial network analysis to answer questions relative to the spatial as well as the social structure of a network and to the identification of key individuals at different spatial scales. The emphasis on scale and the introduction of novel and original metrics are the most useful and interesting aspects of their work. The stated focus of their research is on nodes rather than edges, which remain understudied in the literature on spatial social networks.

While related to the literature discussed above, our research differs in fundamental ways from it. Most significantly, rather than analyzing large, interconnected networks, we are interested in a multitude (in excess of 50,000 for this project) of small networks composed of individuals linked to each other by a family

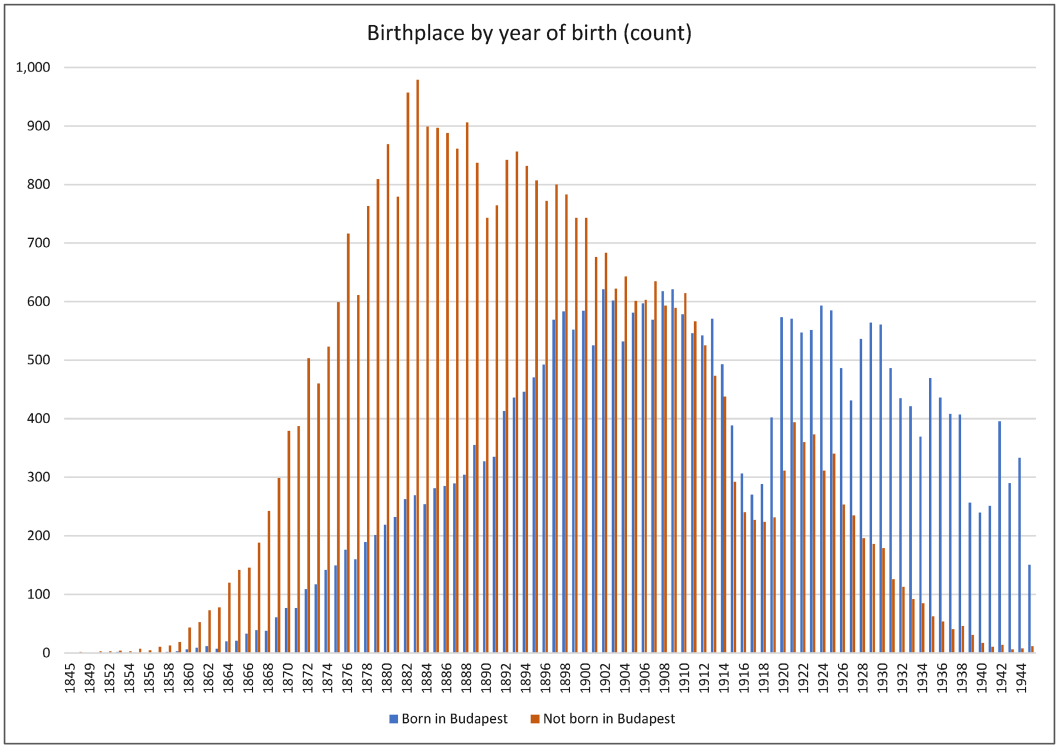

FIGURE 5 Birth year and birthplace of Budapest's Holocaust survivors

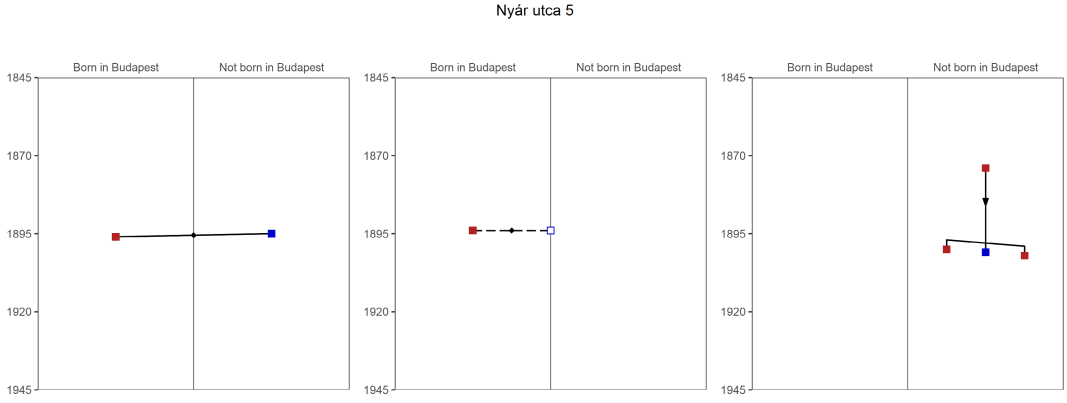

FIGURE 6 Family groups living at Nyár utca 5

relationship. In this type of network, nodes are individuals and edges are defined by relationships of the familial kind (mother, father, sibling, etc.). Our emphasis is, first and foremost, on edges rather than nodes. Our work is also different in that we incorporate the treatment of uncertainty right at the beginning of the development of the model, both in conceptual ways through the design of the scripts, and by the role of the researcher in evaluating the output of said scripts. Furthermore, we deal with uncertainty both as concerns nodes and edges. Another aspect of our work that we want to highlight is that while we are dealing with many small networks, the model we developed allows for the comparison of such small networks, no matter their number. Finally, once family structures are identified, we mapped them in a historical GIS, which allows for the

First run:

INFO [2022-01-04 20:59:34] Miklósné Lindenfeld is maybe sibling of Lajosné Müller : Mother #1 is Fingerhut Regina, Mother #2 is Fingerhut Regina (Last names discrepancies)
INFO [2022-01-04 20:59:39] Lajosné Müller is maybe sibling of Miklósné Lindenfeld : Mother #1 is Fingerhut Regina, Mother #2 is Fingerhut Regina (Last names discrepancies)
INFO [2022-01-04 20:59:48] Laszló Schulhof is maybe sibling of Jakabné Grünhut : Mother #1 is Klein Roza, Mother #2 is Klein Roza (Last names discrepancies)
…
INFO [2022-01-04 21:02:16] Address discrepancy: Schwarcz Rózsi (address: Dobozi utca (-)) and Schwarcz Emilia (address: Dobozi utca 19) are siblings but have different address
INFO [2022-01-04 21:02:46] Address discrepancy: Steiner Vilmos (address: Dobozi utca 3) and Guttmann Béláné (address: Dobozi utca 27) are related but have different address
INFO [2022-01-04 21:02:50] Address discrepancy: Guttmann Béláné (address: Dobozi utca 27) and Steiner Vilmos (address: Dobozi utca 3) are related but have different address
…

After mistakes and inconsistencies have been resolved in the first run:

INFO [2022-01-02 23:37:43] Laszló Schulhof is maybe sibling of Jakabné Grünhut : Mother #1 is Klein Roza, Mother #2 is Klein Roza (Last names discrepancies)
INFO [2022-01-02 23:37:55] Ervinné Flesch is maybe sibling of Antal Patak : Mother #1 is Deutsch Margit, Mother #2 is Deutsch Margit (Last names discrepancies)
INFO [2022-01-02 23:37:55] Ervinné Flesch is maybe sibling of Béla Patak : Mother #1 is Deutsch Margit, Mother #2 is Deutsch Margit (Last names discrepancies)
…
INFO [2022-01-02 23:40:57] Address discrepancy: Steiner Vilmos (address: Dobozi utca 3) and Guttmann Béláné (address: Dobozi utca 27) are related but have different address
INFO [2022-01-02 23:40:57] Address discrepancy: Guttmann Béláné (address: Dobozi utca 27) and Steiner Vilmos (address: Dobozi utca 3) are related but have different address

Final results:

(a) *Node/individual table*

ID	Title	Last name	First name	Last Name fixed	First Name fixed	Title Maiden name	Maiden name	Maiden Name fixed	Gender	Birth Place	Born in Budapest	Birth Year
CR64394	Özv.	Varga	Istvanné				Goldmann Regina		Female	Kisrét	No	1874
CR53536		Schwarcz	Mór						Male	Ipolyság	No	1906
CR53563		Schwarcz	Mórné				Holcz Piroska	Holczer Aranka	Female	Budapest	Yes	1909
CR53617		Schwarcz	Róbert						Male	Budapest	Yes	1927
CR68354		Weisz	Vilmosné				Grünhut Julianna		Female	Budapest	Yes	1878
CR70066		Zieger	Izidorné				Speiser Regina	Speizer Regina	Female	Zbaras	No	1888

Node/individual table (continued, subsequent columns)

ID	Mother title	Mother	Mother fixed	Address	Address fixed	famID	spouseID	motherID	fatherID
CR64394		Krausz Fanni		Dobozi utca 7-9		solo00013			
CR53536				Dobozi utca 19		fam00052	CR53563		
CR53563		Manheim Berta		Dobozi utca 19		fam00052	CR53536	CR25073	
CR53617		Holczer Janka		Dobozi utca 19		solo00107			
CR68354		Pollák Fanni		Dobozi utca 19		solo00108	_missing_		
CR70066		Lindenblatt Berta		Dobozi utca 19		fam00001	CR70065		

(b) *Edge/relationship table*

	Origin	OName	Dest	DName	Type	FamID	AddressO	AddressD
1	CR70065	Zieger Izidor	CR43731	Patak Antal	6	fam00001	Dobozi utca 19	Dobozi utca 19
2	CR70065	Zieger Izidor	CR43732	Patak Antalné	2	fam00001	Dobozi utca 19	Dobozi utca 19
3	CR70065	Zieger Izidor	CR43733	Patak Béla	6	fam00001	Dobozi utca 19	Dobozi utca 19
4	CR70065	Zieger Izidor	CR43734	Patak Béláné	6	fam00001	Dobozi utca 19	Dobozi utca 19
5	CR70065	Zieger Izidor	CR43738	Patak György	6	fam00001	Dobozi utca 19	Dobozi utca 19
6	CR70065	Zieger Izidor	CR70066	Zieger Izidorné	4	fam00001	Dobozi utca 19	Dobozi utca 19
7	CR30891	Klein Miklósné	CR31937	Kohn Regina	1	fam00002	Dobozi utca 7-9	Dobozi utca 7-9
8	CR31937	Kohn Regina	CR30891	Klein Miklósné	1	fam00002	Dobozi utca 7-9	Dobozi utca 7-9

FIGURE 7 Examples of uncertainty from the first script's output

spatialization of a special type of social network—the family—at a range of scales varying from the individual address to the street and the district.

As an object of academic research, a family is a basic unit of study in many social science disciplines and, as is to be expected, it is defined differently depending on the field of inquiry (Ciabattari, 2016). One especially meaningful difference is between the nuclear and the extended family, as both are of interest in our research. Johnson (2000, p. 625) defines the nuclear family as "a married couple and dependent children," and the extended family

FIGURE 8 Location of Jewish residences, Nyár utca (Nyár utca 19 highlighted)

as individuals "related by blood, marriage, or self-ascribed association that extend beyond the [...] nuclear family." Johnson further specifies that members of an extended family can be related by four potential types of relationships: "(1) Lineal relationships formed by intergenerational linkages; (2) collateral relationships linked through siblings and other kin of similar age status; (3) in-law relationships created through marriage; and (4) fictive kin created out of non-kin relationships, such as play children, Godchildren, or foster children." For this article, we are interested in the first three types of extended family relationships, as the data we have at hand does not allow for the identification of the fourth type, that is, fictive kin.

As is to be expected, the topic of the family, and in particular family separations and the loss of family members, is central in the narrative of Holocaust survivors (Cohen, 2006; Cole, 2015; von Joeden-Forgey, 2010). The Holocaust disrupted and destroyed many families, so in the aftermath of the genocide, individuals increasingly relied on—and lived with—extended family members to palliate the disappearance of nuclear family members. In previous research (Figures 2 and 3), we have proposed two representational models to: (a) explore the spatio-temporal structure of families of Italian Jews arrested between 1943 and 1944 (Le Noc, Giordano, & Cole, 2020); and (b) visualize the structure of the spatio-temporal trajectories of two individual victims of the Holocaust (Giordano & Cole, 2019). Of the two models, the latter is explicitly built around three components of place discussed earlier—location, locale, and sense of place—while the first is especially about extended families.

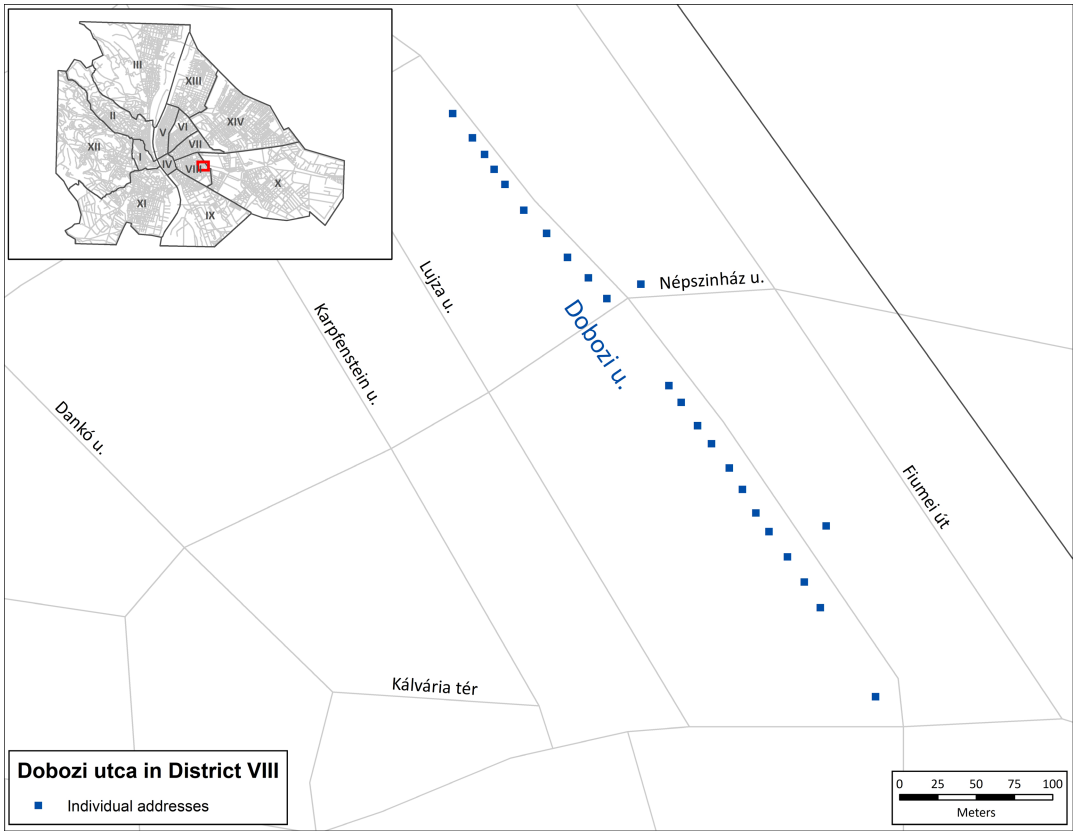

FIGURE 9 Location of Jewish residences, Dobozi utca

3 | THE MODEL

The model we propose in this article seeks to answer two fundamental questions: first, how can representations of social and spatial networks move beyond the tendency to a-historical and a-geographical representation to embed those histories and geographies in the representation? We seek to answer this question by proposing a model of a simplified representation of social and spatial networks that incorporates chronology, location, and locale into the representation. Second, how can representations of social and spatial networks grapple with questions of uncertainty that are so central to humanities data? This is a broader issue that we have explored in earlier work vis-à-vis GIS (Giordano & Cole, 2018, 2019) and continue to explore here, as many of those challenges are relevant to the discussion of models of social and spatial networks.

The model enables a simplified representation of family groups (FGs) to allow for comparative analysis. The model draws from the literature on microhistories, social networks analysis, geography and GIScience, and Holocaust Studies, and reconstructs the social history of selected neighborhoods in 1945 Budapest as anchored in place, people, and networks. The model offers a graphical solution to the challenge of representing spatial social networks that incorporate the historical dimension—they include, in other words, context—as well as recognize cultural limitations and constraints—for all social networks are rooted in culture and society. The model also explicitly incorporates and visualizes uncertainty in its formulation. While all geographical datasets are inevitably saddled with an amount of uncertainty, this is an especially thorny issue with historical geographical datasets, that is, with datasets that cannot be collected again or field checked. Figure 4 includes the components of the model, a

FIGURE 10 Number of residents, Nyár utca

legend, and two examples from one street in post-war Budapest: Nyár utca (street). The model contains a number of elements:

1. It identifies and differentiates individuals by a number of key variables (a) gender, through color; (b) age, through placing by birth year on the *y*-axis; (c) place of birth, through placing on the *x*-axis that is divided into the binary of born in Budapest and not born in Budapest; and (d) certainty/uncertainty of the data, through a mixture of shading and placing on the middle point of the *x*-axis;
2. It identifies and differentiates familial relationships between individuals through symbols representing: (a) husband–wife; (b) parent–child; (c) sibling; and (d) certainty/uncertainty of the data through the use of dashed and dotted lines;
3. It incorporates the sociolinguistic particularities of the data through the use of symbols of individuals and relationships to incorporate those not included in the database; and
4. It places these family groups in their physical surroundings—both within multi-occupancy apartment buildings (noting possible relationships between family groups) and along the length of the street, and at different resolutions the district or city as a whole.

The model is both a visualization and an analytical tool to explore patterns of spatial distribution of family structures in post-Holocaust Budapest. To do so, we created two sequential scripts that parse the 70,000 records, build individual networks from family relationships it identifies, and then create as many separate visualizations (the "boxes" in Figure 4) as there are families. In the boxes, which are of equal size, individual members of the family are nodes, identified by the variables date of birth, gender, and place of birth. Their kin relationships are

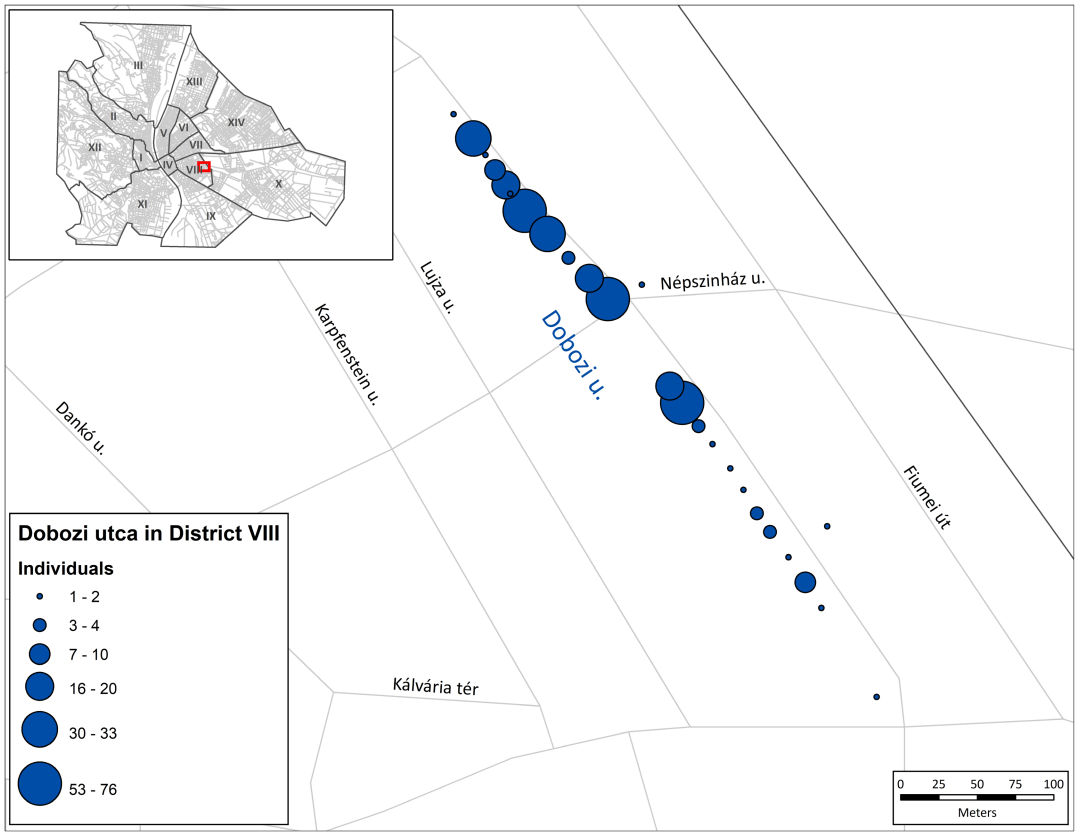

FIGURE 11 Number of residents, Dobozi utca

edges or links, with one variable coded (the type of relationships: mother, father, daughter, etc.). Note that in the boxes in Figure 4, the vertical axis is measured on a continuous scale (birth year), but the place of birth is a binary (born in Budapest vs. not born in Budapest), as this is meaningful in the context of Budapest's Jewish history, as demographic patterns shifted across the course of the second half of the 19th century into the first half of the 20th century from most Jews being born outside the city and being immigrants into it, to most Jews being born in the city and residents of it (Don & Magos, 1983). Coming at the turn of the century, this shift can be clearly seen in Figure 5. Nodes located in the top part of the boxes indicate older individuals, with younger ones in the bottom part. So, in terms of family structures, grandparents are in the top part, parents in the middle, and children at the bottom. The more nodes and the more edges in a box, the larger the size of the family group.

The first script we developed is designed to identify family relationships between individuals in the database using explicit (maiden name of the mother) and implicit (last names) information about these relationships, including information that is specific to the Hungarian language, that is, the fact that wives are renamed with the first and last name of their husbands, to which the "né" is added. The script compares the records of each individual in the database with those of every other individual and look for matches between the names of the known kin of the first individual and the names of kin of others: for example, if the name of the mother of the first individual matches the name of the mother of the second one, and if their last name at birth is the same, then a match is found and the two are siblings. The script also flags likely but incomplete or uncertain relationships, including cases in which last names are spelled slightly differently and in which individuals may be family members but are living at different addresses. Researchers can then review these cases to manually correct them if they believe that individuals are indeed related and/or that spelling mistakes have been made. In order to keep track of the

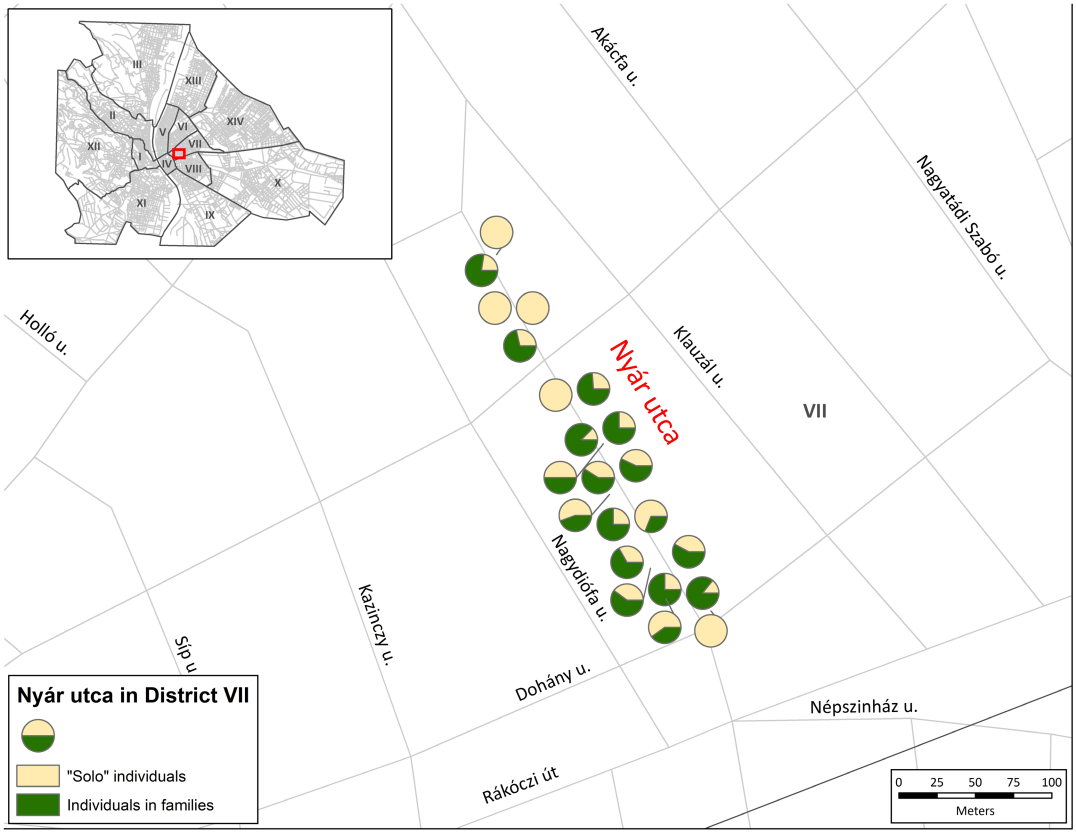

FIGURE 12 Proportion of individuals in family groups, Nyár utca

original data, the modified data are stored in additional columns in the database. The script is then rerun with the updated information, returning two separate files: (1) the original list of individuals with new information, including a family ID common to all members of the same family group, as well as the ID of the mother, father, and spouse of each individual if they are also in the database; and (2) a list of all relationships between any two individuals, with a code to identify the type of relationship (1 for siblings, 2 for father–child, etc.). We will return to this point with an example in the next section.

The second script takes the output of the first and applies a set of rules to create the visualization presented in Figure 4, in which individuals are nodes and relationships are edges. The rules are essentially those presented in the legend: different colors for the nodes based on gender and certainty of the data, position of the nodes based on the place and date of birth, and relationships placed between the node with symbology depending on the type and certainty of the relationships. Additional rules are implemented to avoid as much as possible the overlap of both nodes and links. For each family group, links and nodes are placed on the same background square grid. The scripts then align all the family groups graphs for one building and output one summary image for the building. Although, by default, this second script treats all the family groups of one single building, it can easily be modified to sequentially work on several buildings, for instance, all buildings in one street.

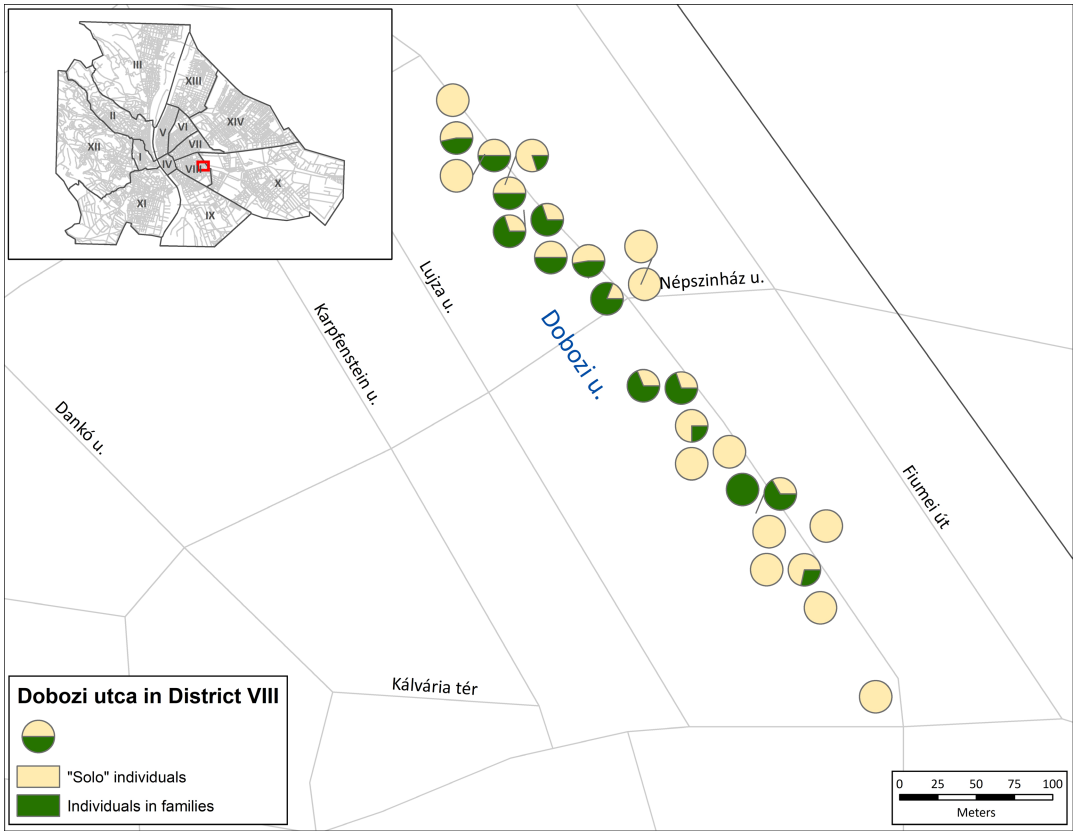

FIGURE 13 Proportion of individuals in family groups, Dobozi utca

4 | DISCUSSION OF RESULTS

As an illustration of the descriptive and analytical potentialities of the model, we have selected one street in the city's VII district, Nyár utca, where Jews had historically lived before the war, were living through a series of ghettos in 1944 (Cole & Giordano, 2014) and continued to live in the summer of 1945 when the door-to-door survey was undertaken. Nyár utca was, in other words, a Jewish place (Giordano & Cole, 2018, 2019). To illustrate how to read and interpret the visualization, we turn our attention to the three family groups (FGs) living in the summer of 1945 in the apartment building at Nyár utca 5 (Figure 6). The first comprises a husband (born outside Budapest in 1895) and wife (born in Budapest in 1896). The second is made up of a single married woman born in Budapest in 1894. The third comprises a widowed mother (born outside Budapest in 1874) and her three children: a daughter born outside Budapest in 1900, a son born outside Budapest in 1901, and another daughter born outside Budapest in 1902. In the case of the second FG, we know from the data that the woman born in Budapest in 1894 is married with her husband still presumed alive. As already noted, at this time and still largely today, Hungarian women took their husband's name in entirety at marriage (with the addition of the suffix "né") and continued to keep this name after their husband's death (with the addition of the prefix "özv"). Thus the data make clear who was married to a husband presumed alive (FG2) and who was widowed (FG3). In the former cases—and there are many given the widespread experience of husbands not yet returned from labor service, or final confirmation of a man's death still outstanding—we have represented the uncertain status of these "ghost husbands" through the use of a dotted line and non-shaded blue square located in the center of the box. Here, we seek to represent both the certainty in the data (the woman in FG2 was married) and the uncertainty in the data (the date and place of

FIGURE 14 Family size, Nyár utca

birth of the husband in FG2 were unknown and indeed whether he was still alive or dead was unknown in 1945). Thus, uncertainty becomes part of the visualization and is explicitly represented in the model when it is present in the data itself.

"Ghost husbands" are only one type of uncertainty we dealt with in the analysis. To dig a little bit more on this issue, we return to the first script. At that stage, the script flagged likely but incomplete or uncertain relationships, including misspelling of last names and cases in which individuals may be family members but are living at different addresses. The survey is a snapshot of a moment and a place in time (Budapest in 1945, the immediate aftermath of the Holocaust), collected door-to-door among a population understandably hesitant to share too many details about their Jewish family, and put together and published quite quickly immediately after the survey was completed. It contains, therefore and inevitably, many spelling mistakes and transcription errors. We corrected many of these mistakes during the course of the preparation of the database of 70,000 and the creation of the HGIS. The script allowed us to catch additional inconsistencies and mistakes, which we then reviewed to manually correct when we believe that individuals are indeed related and/or that spelling mistakes have been made. This manual intervention is a necessary and unavoidable step in working with historical geographical datasets, at least in our experience. Figure 7 shows the output of the script. The first six lines include examples in which possible errors in the last name and address of the individual were most likely the results of typographical errors as well as of potential inconsistencies in the data (e.g., individuals with the same mother but different last names at birth), while the successive six lines highlighted uncertainties remaining after the typographical errors were fixed and after other corrections were made by hand after a careful assessment of the individual records. The tables show the result of running the script after uncertainties were resolved: a node/individual table, with information about

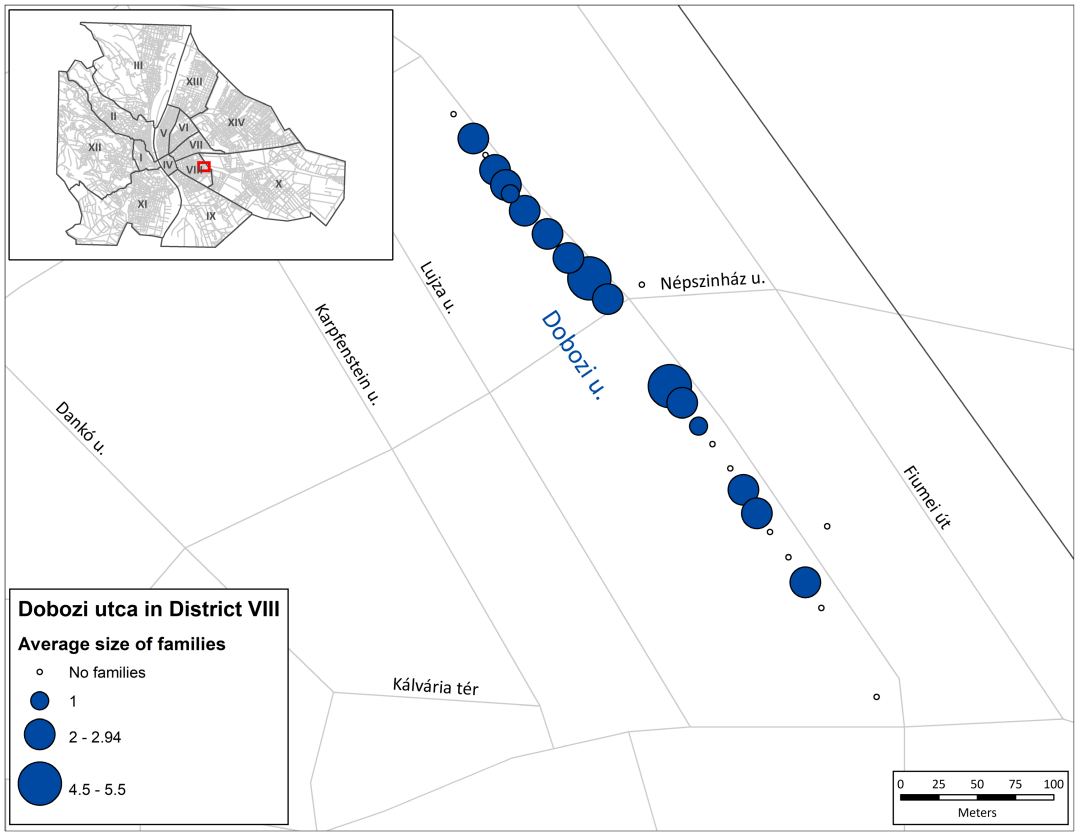

FIGURE 15 Family size, Dobozi utca

the individual, and an edge/relationships table, in which individuals are listed by the type of family relationship they have with each other (mother, father, spouse, etc.), the address they live at, and the family group they belong to. So, for example, Zieger Izidor and Zieger Izidorné are married to each other ("spouse" is "4"), are members of the same family ("fam0001"), and live together at Dobozi utca 19. (Note that, therefore Izidor is not a "ghost husband.")

To illustrate the analytical outcomes of the model, we compare two streets: Nyár utca and Dobozi utca, located less than a mile away from each other in districts VII and VIII, a working-class section of the Pest half of the city. The number of Jewish individuals living in Nyár utca is equal to 280, distributed in 22 individual addresses, while Dobozi utca has a larger population of 357 individuals, distributed in 22 individual addresses (Figures 8 through 11). Note that one side of this street was at the time occupied primarily by industrial premises. The average number of individuals per address—recall that these are all apartment complexes—is larger in Dobozi utca (13.7) than it is in Nyár utca (12.7). For both streets, a little over 60% of individuals live in family groups of two or more individuals, with 40% living alone (Figures 12 and 13): the high number of single individual family units testifies of the destruction of Jewish nuclear families, evident even in cities like Budapest where there were no widespread deportations. The average family size (not including individuals living alone) was also similar, with 2.86 for Nyár utca and 2.91 for Dobozi utca (Figures 14 and 15). In both streets, the majority of family groups includes only two individuals (39 of 74, or approximately 53%, for Dobozi utca and 27 of 59, or approximately 46%, for Nyár utca), but large families of six or more individuals are also present, including one with 10 members in Dobozi utca. Overall, Dobozi utca has both more small families and more large families than Nyár utca, while the size of family groups in Nyár utca is less varied. In terms of types of family relationships, the script identified an average of 1.35 relationships per individual in Nyár utca and 1.65 in Dobozi utca, a reflection of the larger family size in

Dobozi utca than Nyár utca. If we consider only individuals belonging to family groups, the average number of relationships per individual for Nyár Utca is 2.13 compared to 2.74 for Dobozi Utca. The script also identified the types of relationships between family members: sibling, mother, father, spouse, child, and others, with others corresponding to extended family relationships, including uncles and aunts, grandparents, in-laws, etc. One aspect, we were interesting, was the identification of "ghost husbands," and here both streets show a large number of such cases, 45 in Nyár utca and 66 in Dobozi utca, with similar ratios between ghost husbands and total number of Jewish individuals (0.16 and 0.18, respectively) in both. The absence of husbands, and thus oftentimes of fathers, is confirmed by comparing the percent of relationships identified as "father" (4.5%) to that of "mothers" (13.2%).

Overall, then, when the two streets are compared, Dobozi utca is characterized by larger family groups living in extended families, while Nyár utca has more nuclear families of slightly smaller sizes. In terms of geographic distribution, as the maps in Figures 8 through 15 show, in both streets, the distribution of individuals is uneven, with the northern portion of Dobozi utca and the southern portion of Nyár utca more densely populated. As concerns, the proportion of single individuals to family groups, a pattern of concentration is more evident in Dobozi utca, where 11 of 26 addresses (42.3%) only have one resident, while in Nyár utca the distribution is more uniform, with only five of 22 (22.7%) addresses with one resident.

Overall, for the two streets, the scripts produced a total of 385 boxes: 213 for Dobozi utca and 172 for Nyár utca, each corresponding to a family group or an individual. We do not have the space to include them all in the article, but they are available online. When implemented at the level of the entire city, we can predict that the script will produce anywhere between forty and fifty thousand such boxes, a frankly unmanageable number of visualizations. For this reason, we see the boxes as a visual tool to complement GIS mapping and analysis, as shown in the maps in this article, and to more traditional statistical charts, diagrams, pies, etc. They can be used most effectively, we believe, for comparing streets in different neighborhoods of Budapest. As Figure 4 illustrates for Nyár utca 19 (see Figure 8 for its precise location), the boxes allow the researcher to appreciate the variety of family structures existing at the address, including the presence of "ghost husbands" and of multigenerational and extended families in a way that the GIS cannot. They also enable visualizing the place and date of birth of individuals and family members and thus explore if patterns exist in the location of individuals at the street, neighborhood, and district levels as concern their age and place of birth. This last aspect is especially interesting in the context of Jewish history and the Holocaust as Jewish demographic patterns in Hungary shifted across the course of the second half of the 19th century into the first half of the 20th century from most Jews being born outside the city and being immigrants into it, to most Jews being born in the city and residents of it (Don & Magos, 1983).

5 | CONCLUSIONS

We believe the model we propose has the potential to contribute to the study of the geography of families and to Holocaust and genocide studies, as well as to GIScience. As concerns geography, a decade and a half ago Valentine (2008) wrote that the family was an "absent presence" within the discipline, and although in recent years the idea of "family geographies" as a distinct sub-discipline has begun to emerge (Pimlott-Wilson & Hall, 2017; Tarrant & Hall, 2019), the need for a geographical theorization of the family, and the methodological tools to study it, remain relevant today. Our work is an attempt at providing tools, if not theorizations. As concerns, the Holocaust, Pine (2004) points out that there has been relatively little research on families in Holocaust Studies, and when this is the case, the focus is typically on issues related to gender and gender roles or on the experiences of women and children, although a handful of scholars have extended their gaze beyond these topics, including Ofer (1999), Iskov (2011), and Weitzman's (2017) examination of family structures. The work we present here is along these lines, as it aims at studying how the Holocaust fundamentally changed the traditional structure of the Jewish family, doing so not from a qualitative perspective but from a quantitative one and with visualization methods.

As we have suggested, the chronological and temporal specificity and complexity of this immediate post-war moment in one city is something that we have sought to include in a model of social networks that, by definition, simplifies. But we have also, as we note, sought to include another layer of complexity that characterizes working with the kinds of degrees of uncertainty found in historical sources. We argue, expanding on Drucker (2011) that social network analysis needs to grapple with representing "capta" and not only data in ways that are sensitive to sociolinguistic cultures and temporal-spatial practices. In short, there is a need to allow the metadata to intrude into the representation of the data. Herein lie some of the major challenges we are facing in extending our analysis to the entire dataset, as the list contains ambiguities that are difficult to address and reconcile. Two are worth mentioning here: (a) the dataset includes 7565 last names, ranging from the most common (Weisz, with 1913 individuals) to 3016 cases with only one individual, and while the Hungarian language simplifies the work of reconstructing family groups, much uncertainty still exists; and (b) it is sometimes very difficult to map with certainty the place of birth of the survivors, due to the tormented history of this part of Europe, as the same village could alternatively have been part of Poland, the Austro-Hungarian Empire, Hungary, or the Soviet Union, changing name along the way.

In addition to highlighting issues related to the uncertainty of data, and the explicit incorporation of uncertainty in the graphical representation, we believe our work contributes to spatial social network debates in other ways. First and foremost, we are convinced that in order to be meaningful in a geographic sense and as a way of understanding place—as much spatial social network research aims to do—the discourse around this type of network needs to be contextualized both historically and culturally. As this case study has shown, for example, "ghost husbands" can be identified only because of how married women change their names in a predictable and standard way in Hungary. This is quite a unique characteristic of the Hungarian language and society, one that does not apply in other contexts. Contextualizing spatial social networks is important not only when studying families and social networks more in general but, perhaps even more so, for future research on platial GIS, or the GIS of place. We do not have the space here to discuss this issue in depth (we do so in Giordano & Cole, 2019), but—very briefly and simplifying the argument—if we define place following Agnew and Tuan (Agnew & Duncan, 1989; Tuan, 1977) as being constituted by location, locale, and sense of place, with locale being intended largely as the spatialization of social networks, the recognition that both the nodes and the edges have ontological status depending on their culture and history needs to be taken into account. Put it another way, progress in spatial social network research needs to progress along qualitative as well as quantitative methods of analysis. The challenge is, of course, how to build a functional model, including metrics, that incorporates both. For example, the visualization of family relations as represented in our model lends itself well to the development of metrics based on the shape of the resulting graphs and on the measurement of distances, both topographic and topological, that can be generalized to other examples of social networks. This will be the subject of future work we are now embarking on.

One characteristic of our model that makes it generalizable is that the dimension of the box and the topological structure of the family links are constant so that the specific shape and size of one particular representation—for example, the two individual residences in Figure 4—is comparable across the entire range of addresses. This allows us to study how the Holocaust reconfigured the structure of the Jewish nuclear family—for example, multigenerational families are common, as are families in which one parent (in particular the father) is absent or the complete absence of family seen in those many individuals living alone—as well as to explore how family structures varied across the city—an important point as Jews coming to Budapest from other parts of Hungary tended to form communities based on where they came from. This last observation allows us to highlight one area of application in which the model we propose may be especially useful: migration studies. The model explicitly maps two elements of the place as we theorized it—location and locale—and does so using a dataset that is analogous to a modern census. In this sense, we can envision an application that would reveal the location and locale of migrant families in a particular community with a focus on kinship networks.

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CONFLICT OF INTEREST

There are no conflicts of interest we are aware of.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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