AperTO - Archivio Istituzionale Open Access dell'Università di Torino

Finding a Secure Place: A Map-Based Crowdsourcing System for People With Autism

This is the author's manuscript

Original Citation:

Availability:

This version is available http://hdl.handle.net/2318/1752828 since 2023-01-27T09:54:43Z

Published version:

DOI:10.1109/THMS.2020.2984743

Terms of use:

Open Access

Anyone can freely access the full text of works made available as "Open Access". Works made available under a Creative Commons license can be used according to the terms and conditions of said license. Use of all other works requires consent of the right holder (author or publisher) if not exempted from copyright protection by the applicable law.

(Article begins on next page)

07 May 2024

Finding a Secure Place: A Map-Based Crowdsourcing System for People with Autism

Amon Rapp, Federica Cena, Claudio Schifanella, and Guido Boella

Abstract— **People with autism have idiosyncratic sensory experiences, which may impact on how they live the "spaces" of their everyday life. Starting from an investigation of their conception and experience of "secure places," we defined a series of user requirements for designing technology that supports their everyday movements in the urban environment. On the basis of such requirements, we developed an interactive system that leverages crowdsourcing mechanisms to map places that are perceived as secure by the population with autism.**

Index Terms— **Autism; crowdsourcing; maps; spatiality; human-computer interaction.**

I. Introduction

Autism entails an atypical social functioning, which often results in avoiding everyday interactions [1]. Individuals with autism appear also to react differently to sensory stimulations [2]: a majority of them may become overwhelmed by environmental features that are managed easily by "neurotypical" persons, namely all those people not belonging to the autism spectrum. People wit autism further tend to find reassurance in rigid routines. This leads to problems in managing unexpected events, which may turn into high levels of anxiety [3]. Symptoms of autism span from severe language and intellectual disabilities in individuals with low- or mid-functioning autism, to no disabilities and an Intelligence Quotient (IQ) above the average in persons with high-functioning autism and Asperger's syndrome.

Developing technologies addressed to people with autism primarily entails the understanding of their "neurodiversity": coined in the late 90s, this term advocates the rights of individuals with autism, recognizing their perceptual and cognitive abilities [4].

This paragraph of the first footnote will contain the date on which you submitted your paper for review. This work was supported by the Compagnia di San Paolo. (*Corresponding author: Amon Rapp*)

A. Rapp is with the Department of Computer Science and the ICxT - ICT and Innovation for Society and Territory, University of Torino, 10149 Torino, Italy (e-mail: amon.rapp@unito.it).

F. Cena is with the Department of Computer Science and the ICxT - ICT and Innovation for Society and Territory, University of Torino, 10149 Torino, Italy (e-mail: federica.cena@unito.it).

C. Schifanella is with the Department of Computer Science, University of Torino, 10149 Torino, Italy (e-mail: claudio.schifanella@unito.it).

G. Boella is with the Department of Computer Science, University of Torino, 10149 Torino, Italy (e-mail: guido.boella@unito.it).

For long time, the neurodiverse condition has been inserted into a "medical model," which defines "being disabled by people's physical or cognitive differences and the resulting functional limitations" [5]. This model certainly offers advantages, as it allows to easily define requirements for development, based on the alleged "limitations" of the autistic population. Recently, the Human-Computer Interaction (HCI) community advocated the need to grasp the richness of the autistic experience, recommending that we explore novel approaches [6]: these should allow us to figure out what is really meaningful in the life of individuals with autism and develop technology embedded in their experiential world [7].

A theoretical framework that may account for the autistic experience is that of phenomenology. Phenomenology is grounded in the seminal works of Husserl, Heidegger, and Merleau-Ponty [8], and explains the world as constructed through sense-making by a "subjective point of view." In HCI, it has been employed e.g., as a frame to understand tangible interaction [9] and to ground the development of self-tracking devices [10]. Phenomenology accounts for how individuals interpret their own existence [7], offering tools to analyze the autistic individuals' world "from the inside."

In this article, we aim to explore how people with autism experience and make sense of the places they perceive as "secure," in order to design an application that may ease their "city life," a topic that is still underexplored in both the autism and HCI literature. We started our research from studies on cognitive urbanism [11], which explore how people "perceive" and "understand" the spaces they live in, thus matching with the phenomenological approach we follow. Then, we formulated the following research questions: What do individuals with autism consider a secure place? What do they avoid during their daily transfer? What is harmful for them? How might technology support them in finding secure places? The collected results led to the definition of a series of user requirements which have been used to design a crowdsourcing system that supports individuals with autism in moving across urban environments. The research has been approved by the ethical committee of our University.

II. Background

HCI researchers widely employed technology to support people with autism in managing specific problems, as they commonly exhibit an affinity with technology [12]. Nonetheless, HCI research on autism tended to pay attention to children [13], overlooking the adults' needs. This might be a consequence of the "medical model" we described above, which promotes intervention toward school-aged individuals. Moreover, the HCI community preferred to address social interaction problems, likely because these are seen as the core characteristics of autism from a clinical point of view: scholars, therefore, focused on e.g., face-to-face conversation [14] and emotion management [3], ignoring other difficulties.

A relevant domain that impacts the daily life of adults with autism is that of "spatiality." Different anecdotal recounts made by people with autism point out a difficulty with orientation and navigation (e.g., getting lost in their own neighborhoods due to a bus diversion [15]). It seems that they are less likely to explore new environments, and more likely to return in well-known locations than neurotypical individuals [15]. These peculiarities may entail idiosyncratic modes of perceiving and making sense of space. Nevertheless, we still have little knowledge about autism spatiality [15].

In fact, the attention of the HCI community toward the autistic users' spatial needs has been very limited. Commonly, HCI researchers focused on making city spaces accessible to people with physical disabilities [16-17]. An exception to this tendency can be found in [18], where requirements for developing transportation systems accessible to users with cognitive disabilities are formulated. However, this work does not specifically target individuals with autism. [19] studied a variety of locomotion techniques with people with autism in Virtual Reality, suggesting a series of interaction guidelines, which, nonetheless, remain circumscribed to the virtual world; whereas [20] developed an application that enhances the autistic individuals' physical proximity awareness: nevertheless, they still focused on social interactions. A more prominent attention to the ways of perceiving "space" of people with autism is thus in need.

In the early '60s, Lynch used interviews and "cognitive maps" to explore how people perceive the city spaces they inhabit. He asked citizens of three different US cities to surface their distinctive elements. It turned out that people perceive an urban environment as an image constructed by cognition, namely a "phenomenological," fundamentally subjective, representation of its space [11]. Lynch emphasized that, even though each person builds an idiosyncratic image of the city, we may find agreement among people belonging to the same "group." Having peculiar ways of appraising the world, like those characterizing the population with autism, may thus affect the representations of cities. Lynch's work became extremely popular and influenced social scientists, urban planners and psychologists [21]. In HCI, Lynch's research has been used to create a virtual city [22], and make city neighborhoods more quiet and beautiful [23].

By building on Lynch's research, we explore how people with autism experience those city environments that make them feel "secure." This goal entails the "phenomenological" understanding of the subjective feelings and meanings through which they make sense of their world. This would result in technologies that may satisfy their idiosyncratic spatial needs. In doing so, rather than paying attention to what a person with autism cannot do [24], we focus on her idiosyncratic experience of the world, changing perspective from helping to empowering, and thus going beyond the medical model.

To this aim, we conducted a *preliminary exploratory study* to grasp the autistic people's subjective experience of urban environments [25]. We interviewed six participants with high-functioning autism/Asperger's syndrome and six participants with mid-functioning autism. An overview of the study results can be found in [25]. Here, we want to summarize some key findings, which motivated us to conduct a new study.

First, all mid-functioning participants perform very rigid "spatial routines," traveling along the very same paths and hanging out at the same places. They autonomously move only between home and close or well-known places (e.g., a specific park), whereas they are assisted by their caregivers for every other transfers. However, such participants have scarce interest in knowing new places. High-functioning/Asperger participants often hang out in the same locations as well. This tendency seems to be only partially due to a scarce interest in exploring novel environments. As a matter of fact, it origins from the anxiety that unexpected situations may engender.

Second, individuals with autism (both mid- and high-functioning) feel safe primarily at home, since they feel to exert control over its environment. This control is related to the possibility of regulating its physical features according to their sensory sensitivity. This means that the lights and the temperature of the rooms can be adjusted to their changing needs, as well as the smells coming from the outside can be covered with the scents they like the most. The impossibility of exerting the same degree of control over the "space outside" leads individuals with autism to spend most of their time at home. However, while mid-functioning participants show a scarce interest in "going outside" feeling at ease in their home, high-functioning participants are aware that this attitude is counterproductive, because it may lead to seclusion.

In sum, this preliminary research highlighted that individuals with autism need to feel "secure" when they "go outside." We then decided to investigate more in depth this fundamental need by conducting a new *user study* focusing on high-functioning/Asperger individuals, as the frequency and variety of their daily movements (they commonly travel for work and/or are involved in daily activities requiring transfers) entail a more relevant need to use technology to find spatial support. Mid-functioning participants, instead, do not show the need to go outside, and when they do so they are accompanied by a caregiver. We recount the findings collected in this new study in the following Section.

III. User Study

A. Method

We recruited 20 (P1-P20) individuals with high-functioning autism / Asperger's syndrome (autism level 1 in accordance to DSM-5; females=2; avg. age=26.5). Nine were university students, 4 unemployed, and 7 had a full-time job. They had an IQ ranging from average to high. Some of them had high level competences e.g., in mathematics or music. Some participants had difficulties in decoding certain information (e.g., double meanings), and had the tendency to pay attention to details rather than the wider context. All of them owned a smartphone. We differentiated the sample by recruiting people inhabiting the city of Torino (a big city with almost 1 million of inhabitants), as well as residing in satellite towns (less than 50 thousand inhabitants). The participants were recruited and screened by the Adult Autism Center, in the Department of Mental Health of ASL City of Torino in Italy, by following DSM-5 criteria. The decision of settling for twenty participants came when we became aware that additional data would not have entailed substantial new findings for the goals of our study, thus following the criterion of data saturation [26]. Other HCI research employing a similar study design has opted for similar sample size [27].

To grasp their subjective experience of city spaces we used semi-structured interviews. This method was chosen as it has been successfully employed to collect user requirements with people with autism [28]. Participants did not have difficulties in language production: therefore, inviting them to directly report their perception of "spatial safety" was the best way to capture their subjective experience, in line with our phenomenological approach. Albeit people with autism might find it uncomfortable to be engaged in social interactions, this may be mitigated when they know in advance how the conversation would evolve. Then, we carefully explained the goal of the study and the questions being asked at the beginning of the interview. All the participants appeared to be at their ease during the study. Examples of interview questions are: *What does it mean to be in a secure place for you? What kind of features does this place have? What does it mean your home for you? What does it hurt or annoy you more when you are outside? Can you describe some situations in which you felt insecure?* Participants could discuss topics not present in the questions we asked. Interviews lasted about one hour each, were audio recorded and transcribed verbatim.

The findings were analyzed through open and axial coding [29] and manually coded by the first and the second authors independently: they took apart sentences assigning them labels like "using technology" or "crowd". Then, they reviewed together the generated open codes and resolved inconsistencies, which mainly revolved around differences in the way the two researchers labeled the same concepts. The codes were then grouped separately by the two authors through axial coding, labeled and compared again, eventually producing nine abstracted categories. Selective coding entailed three overarching categories, which represent the key themes resulting from the analysis: *sensorial aversions*, *narrow interests*, and *familiar places*.

B. Findings

By and large, the findings confirmed the preliminary data collected in the exploratory study, pointing out a more multifaceted picture. In the following, we will focus on the three themes emerged during the data analysis.

Sensorial aversions. The interviewees affirmed their high sensitivity to sensorial stimulation, emphasizing their sensorial "aversions." All participants reported to actively avoid places or routes that may negatively impact on their senses. They explained that sight, smell and hearing are the relevant senses with reference to mobility in city environments. Most (14 out of 20) showed to be negatively influenced by a high sensorial stimulation in two or more senses (e.g., hearing and sight). However, there are no places' characteristics that may reassure the entire autistic population. For instance, P1 reports that he is not annoyed by strong smells or loud rumors, but is hurt by the visual features of a place, especially by vivid colors and strong lights. P7 says that he avoids too silent environments, and that the narrowness of a place impacts on his comfort.

Participants identified further relevant environmental dimensions that could affect their sense of safeness, namely the temperature, openness, and crowding of a place. Some participants pointed out the need to escape from places that are too cold (3 out of 20), too hot (3 out of 20), or both (4 out of 20). Others stressed their aversion toward narrow places (6 out of 20) or open spaces (3 out of 20). Finally, a majority of participants (12 out of 20) pointed out the willingness to avoid crowded places. Such idiosyncratic sensorial aversions may result in anxiety, fatigue, disgust, sense of oppression, or distraction. For instance, P9 recounts that "*When there is a lot of noise, loud sounds, I get tired*".

By contrast, comfort is achieved when a given place meets certain sensorial "standards," which often mirror the environmental features of the participant's home. P11 and P12, for instance, pay attention to how the rooms of their houses are heated since they have high sensitivity for high temperatures: outside, they mainly look for air-conditioned places. Home is where people with autism create an environment that perfectly matches their sensitivity, which is more "developed than in neurotypical individuals," as participants explained in their own words. Feeling secure, therefore, primarily means being shielded from some sensorial painful stimuli that may lead to bewilderment or anxiety.

Narrow interests. Participants added that their sense of safeness toward a place is built not only on its sensorial features, but also on the meanings they ascribe to it. Such meanings are mainly related to their interests. In this perspective, home is the secure place par excellence, as its spaces are imbued with the participants' "hobbies." All the participants avoid opportunities for doing novel experiences: their "hobbies" are fixed to a greater extent than those of neurotypical people, as the majority of interviewees note (18 out of 20). This confirms research pointing out that people with autism have narrow interests [30].

A key finding of this study is that people with autism project such interests into the surrounding environments. They categorize the "outside spaces" along their "hobbies," completely ignoring what falls outside. For instance, those participants (5 out of 20) that are interested in nature seek exclusively places that have natural features, like parks and gardens. P19 explains that "*My personal interests are shops, especially tobacco shops, and bars. I'm not interested in anything else*." For these individuals, walking in a park, or going to a library, is a means to recover the "control" they exert over their private place. Their home, in fact, is where they can "encounter" exclusively what they have previously arranged, e.g., the objects, the plants, the books, and the paintings they have chosen. P2 describes how his home is packed with a variety of books, movies, and records, which represent his interests in culture, music, and arts: these make him feel at ease, literally "*secure*," being surrounded by what he really knows and cares of. There is no room for "unexpected elements": everything is foreseeable as it is well known in its characteristics. Likewise, when a place reflects participants' interests, it becomes more predictable: they can focus on what they already know, rather than on the unforeseeable events that may happen in there.

Familiar places. As we have seen, individuals with autism look for environments that are "secure" in terms of their sensorial characteristics and that embed their idiosyncratic interests. However, the possibility of finding in advance information about a new place may further condition their perception of safeness toward it. Reading descriptions or seeing photos about a new place may create a sense of familiarity that reduces the uncertainty of the unknown. To this aim, most of the participants (14 out 20) use map-based technology services, like Google Maps and Google Earth. Such services are used both when they need to go to a new place, in order to figure out how it looks like in advance; and when something unexpected happens and their level of anxiety increases, e.g., if they lose their way while using the public transportation system, in order to find a familiar place nearby.

Despite the usefulness of existing technology, participants also stressed its limitations. On the one hand, current map-based services do not allow them to immediately identify those places that may be secure for them, forcing them to read many descriptions from different sources. This is often not feasible given the level of anxiety they are experiencing, leading to information overload rather than anxiety management. On the other hand, participants emphasized that some of their aversions are specific to the autistic world and can be better understood by people sharing the same condition. In their perspective, small details have a strong relevance to them: P20 explains that "*when I have to choose a hotel the most important things for me are the water pressure of the shower and the hardness of the pillows and the mattress*." Such details, in their opinion, can be accessed only if a large number of targeted "reviews" are available. In fact, the information they need widely varies from individual to individual. Some of them may focus on the visual aspects of a place, while others may need to know something about its sounds or smells. When asked whether they would like to contribute to create such "reviews" all the participants responded affirmatively. However, they believed that solely leveraging the efforts of individuals with autism would strengthen the separation between "us" and "the rest of the world." Instead, involving "neurotypical people" in such an endeavor could reduce this separation.

C. User requirements

On the basis of the collected results we may surface three main characteristics of a "secure place" for an individual with autism, as they are perceived from her subjective point of view. A secure place is i) a *familiar place*, i.e., a place that is already known, or can be known in advance, thus minimizing the risk of encountering unexpected events; ii) a *comfortable place* from the "sensorial point of view," thus not overwhelming the sensorial channels that she feels more sensitive; iii) an *interesting place*, which may embed her interests and hobbies. These characteristics allow us to define a series of user requirements, meant as guidelines to drive the design of a system aimed at easing their daily movements. Such requirements, based on the autistic people's phenomenological experiences rather than on the medical model, could also inspire other researchers to design "spatial services" specifically addressed to them.

Requirement 1. *Provide individuals with autism with information about city places by means of map-based technology support*. This would reduce the unpredictability of the environment. Persons with autism are not necessarily refractory to explore new places: what they fear is not to know what they can expect. Giving targeted descriptions of or suggestions about city locations could lower their anxiety for exploration. Using interactive maps may leverage the familiarity they already have with map-based services.

Requirement 2. *Focus on the sensorial characteristics of the environment*. Individuals with autism primarily look at the sensorial features (brightness, loudness, smell) of a place to define its degree of safeness, also considering its temperature, crowding, and openness. This confirms studies on the sensory experiences of people with autism [2]. Information given about city spaces should highlight such features, making them immediately visible. This would allow people with autism to easily identify the places they consider secure, enlarging their "secure space" outside the boundaries of their home, as well as to avoid those locations that they may perceive as unsafe.

Requirement 3. *Allow individuals with autism to filter out information about places that do not match with their interests*. Persons with autism have narrow interests and tend to ignore what does not match with them. In order to not overwhelm them with information falling outside their circle of interests, places should be categorized, and users should be allowed to display only those pertaining to specific categories.

Requirement 4. *Allow autistic and neurotypical individuals to actively participate in the creation of a knowledge base about the places of their cities*. Participants expressed the willingness to contribute, but also highlighted the need to collaborate with neurotypical persons. This effort could be supported by an "open" crowdsourcing process, whereby diverse people cooperate toward a common goal. Hong et al. [31] showed that crowdsourcing can produce direct answers from "out-group" responders who might give advice as good as that by members of a dedicated autism community.

IV. SYSTEM

Building on the requirements defined during the user study, we created a map-based crowdsourcing system aimed at collecting information about places that might be considered secure by people with autism. The design process followed a participatory design approach [32], in which people with autism have been actively involved in iteratively discussing our design outcomes. We formed a design group, composed of five people with autism who participated in the interview study, an HCI researcher and a psychologist specializing in autism. During the first encounter, we asked participants to consider the defined requirements and then work individually to develop "design ideas" that could satisfy such requirements. Then, the participants presented their ideas to the other members of the group. Afterwards, we explained our preliminary design concepts. Participants discussed how their ideas could integrate into, revise, or substitute ours. By and large, they positively responded to our concepts, enriching them with more nuanced features, and often proposing specific solutions. For example, they suggested that we add a "global" evaluation of places. Subsequent design sessions with the group aimed to preliminarily assess the features we were developing, collecting feedback from the autistic participants.

The designed system is built on FirstLife [33], a civic social network based on a web-based platform that can be accessed by both desktop and mobile devices. The system allows the collection of data from users, integrating them with information coming from heterogeneous data sources (e.g., open data). This kind of georeferenced data is also known as Volunteered Geographic Information (VGI), that is geographic knowledge provided by non-expert crowds. Although administrations and citizens successfully exploited VGI systems to e.g., report city problems [34], their potential to support users' self-organization remains unexpressed [35].

The system entity model includes different types of *first-level entities*. The most important entity type for the project's goals is "Places," which include buildings, streets, open spaces, points of interest from a socio-cultural perspective, etc. A first level entity can be described by a set of core properties. These include the name, the description, the category, the user who created it and the last user who updated it. First level entities can be enriched with second-level entities such as images, ratings and reviews. The system data model implements a set of relations that can be used to connect the entities, enabling the creation of complex urban entities.

The main system interface is composed of a map and a side wall, containing the entities' details in the form of "cards" (Fig. 1). A single entity can be opened by clicking either on map markers, or on their summarized card on the wall, prompting a detailed view that shows all its properties and second-level entities. Users have control over the map visualization, with the possibility to filter contents by category, name, and tags. In addition, the platform can visualize the subset of data corresponding to the "user's map" (containing all the contents generated by that specific user).

All registered users can add places via a stepwise wizard, specifying their categories and information about them. The system addresses the problem of multiple insertions of the same place by suggesting existing entities close to the location selected by the user. Differently from other VGI platforms [36], places are described not only through geographical coordinates, but can be linked to "map units" identified at different zoom levels, like city-blocks and neighborhoods: in this way the system can display only the places associated to a particular "unit," avoiding to overcrowd the map and confound the user. This is enabled by our internal multi-scale topology-aware indexing system, which extracts, from crowd geographical spatial primitives available in OpenStreetMap (OSM) dataset, the map units that are difficult to identify because they are neither institutional nor only physical, linking them to the system's places. In order to extract the map units, we employed a semi-supervised approach that, starting from a Postgres/PostGIS OSM dump, creates a street graph by using PGRouting Postgres library, which is subsequently stored in and processed through the Neo4j graph database [37].

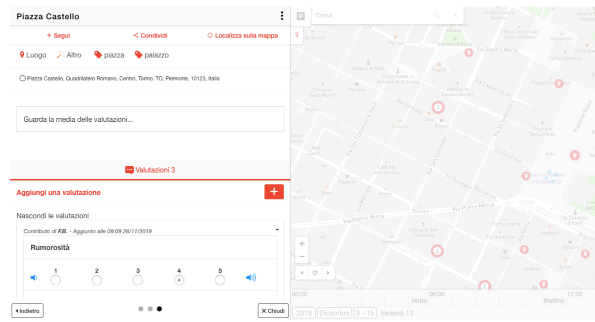

Figure 1: The system desktop interface.

After this step is completed by one user, other users can contribute by adding second-level entities (e.g., ratings). Users are always aware of the activities involving the places they are interested in, as they can "follow" the places receiving notifications about them. They can also share places with other users, inviting them to add ratings and reviews. Differently from common crowdsourcing [38-40] and VGI platforms, our system combines VGI with social network functionalities, by creating a shared working environment to coordinate the initiatives of both autistic and neurotypical people on a local scale. It is the first VGI crowdsourcing system specifically targeted to autistic users, allowing them to add "sensorial ratings" to places, as well as follow and share them; whereas other VGI crowdsourcing systems addressed to people with disabilities focus on physical impairments and do not consider the places' sensorial features [16-18].

The system client is a web application that can be easily used from desktop and mobile devices, thanks to responsive design programming. The frontend is developed by using AngularJS, while maps leverage the functionalities offered by Leaflet framework and the custom FirstLife tile server. The backend of FirstLife is developed using LoopBack: an open-source model-oriented framework based on Node.js technology that provides an easy and extendible way to create end-to-end REST APIs. LoopBack works as an abstraction layer between the business logic and a cluster of databases. The backend can be invoked by the client, as well as third-party applications through the aforementioned REST APIs: for this reason, we are also implementing native Android and iOS apps. The system's APIs use GeoJSON as message format, an extension of JavaScript Object Notation (JSON) for geographical entities. GeoJSON is the standard format for geographical information, supported by all major Geographic Information Systems, helping in term of interoperability. The system uses MongoDB, a NoSQL database. This choice allows to evolve the stored data structure over time while maintaining good performances of geographic queries.

In the following, we detail how the system fulfills the requirements we defined.

Requirement 1. The information about the city places is provided through a map, favoring the spatial contextualization of the data. This kind of visualization is similar to that of map-based services used by many individuals with autism.

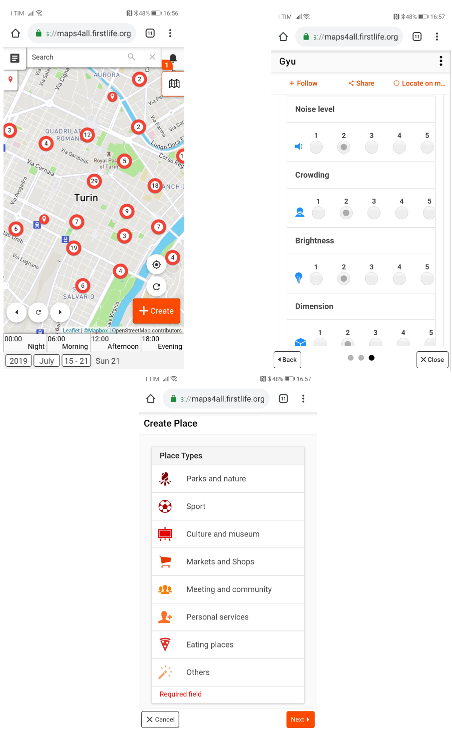

Figure 2: The mobile version of the system (the map on the left, the place's sensorial features in the center, and the form for inserting a new place by selecting a category on the right).

Requirement 2. For each place, it is possible to see a textual review and a visualization of its sensorial features, and in particular its level of i) noise; ii) crowding, iii) temperature, iv) brightness, v) openness, vi) smell. These features have been defined on the basis of the user study findings. A global evaluation is present as well, in order to immediately convey an understanding of the suitability of the place for the autistic population. Data about the sensory features are conveyed through Likert scales, which are meant to intuitively display the features' "levels." The user can access both the average evaluation given by the whole community, and that provided by single users. To address the issue of false reporting, the system currently gives users the possibility of signaling wrong data to the system moderator. As a next step, we will implement a semi-supervised filter based on consensus and outlier detection algorithms [41].

Requirement 3. The user has the possibility to filter the information displayed on the map in order to see only what she prefers. Filters are related to the categories characterizing the places, e.g., parks and nature, sport, culture and museum, market and shops, meeting and community, personal services, eating places, etc. (defined by grouping the interests expressed during the user study). Multiple categories generate multiple map themes, allowing users to explore and filter the map from different perspectives. A search feature is also present.

Requirement 4. The map allows users (with autism and neurotypical) to directly participate in the production of city knowledge. Users can rate a place with reference to the aforementioned six sensorial features, give a global assessment about its "comfort," and provide a textual review. While the environmental highlights may give an intuitive snapshot of a given place, to be used when individuals with autism need to rapidly find a "secure place," reviews may allow to deepen the understanding of the place, when they need to plan a travel in advance. Moreover, users can insert new entities on the map (i.e., new places). To do so, they can select a place directly on the map or search for its address in the search interface; then, they may give it a name and select the specific category to which it belongs. The user can also add tags and external links: tags allow to describe the key characteristics of entities from a user-centered perspective enabling the creation of a crowdsourced knowledge base.

V. Evaluation

A. Method

We recruited 8 individuals (F1-F8) with high-functioning autism (autism level 1 in accordance to DSM-5; females=2; avg. age=28.4;) and 8 neurotypical individuals (S1-S8) (females=4; avg. age=35.2) to gain insights about the acceptability and usability of the designed system. Neurotypical participants were recruited through a snowball-sampling method, whereas individuals with autism were engaged through the Adult Autism Center of Torino. None of them participated to the previous phases of the research. We followed a purposeful sampling method [42], balancing the sample with reference to profession, computer skills and city zone in which the participants lived (e.g., city center of Torino, peripheral neighborhoods, satellite towns) in order to increase its heterogeneity. Four participants with autism were university students, two unemployed, two full-time employed. Three neurotypical participants were university students, one unemployed, four full-time employed. All the participants were unfamiliar with crowdsourcing and reported to be Internet/PC/mobile users. The decision of settling for 16 participants followed a data saturation criterion [26].

The aim of the study was explorative and qualitative in nature. We decided to employ qualitative methods as we wanted to gather rich insights, even unexpected, about how autistic and neurotypical users reacted to our system, rather than to assess our solution with respect to quantitative variables. In line with our phenomenological approach we aimed to grasp their subjective experience in interacting with the system. A researcher introduced the system, which was populated by 40 places and reviews specifying their sensorial characteristics (these places were inserted by both the researchers and people with autism recruited by the Center). Each participant was allowed to freely explore its features and contents. Afterwards, they were asked to perform eight tasks, which covered the different system's features: these spanned from exploratory tasks (i.e., i) finding a specific place by exploring the map, ii) following a specific route on the system's map) to crowdsourcing tasks (i.e., iii) creating a new user profile, iv) creating a new place, v) adding data to an existing place, vi) canceling an existing place, vii) modifying the data of an existing place, viii) reading a review inserted by another user). Tasks were meant as stimuli to identify interaction problems and engender discussion: they were not used to collect measures such as completion time. Four participants with autism and four neurotypical users used an iPhone to access the system, while the others used a PC.

The trial lasted sixty minutes approximately. Participants provided feedback through thinking-aloud protocol. The experimenter observed the task execution taking note of the users' difficulties and comments. At the end of the session participants were interviewed for about 30 minutes. All the thinking aloud sessions and the interviews were audio recorded and transcribed verbatim. Results were analyzed together, following open and axial coding techniques [29]. Data were coded manually by the first and second authors by taking apart sentences and labeling them with a name. Then, they were reviewed segment-by-segment to evaluate consistency in the application of codes, and resolve inconsistencies. Open codes were then connected through axial categories. These were finally grouped into four core categories that parallel the four user requirements we defined.

B. Findings

We did not find relevant differences with reference to interaction between the mobile and the desktop usage of the system. Rather, autistic and neurotypical participants showed to differently perceive, understand and use the system.

Interface. Both neurotypical and autistic participants were able to complete the tasks provided. Neurotypical individuals pointed out usability issues like unclear grouping of the navigation features (5 out of 8), or problems in distinguishing visually the "places" inserted by themselves and the places added by other individuals (4 out of 8). However, they described the navigation modalities as fundamentally intuitive and simple and did not express concerns in finding places on the map. Participants with autism highlighted the same problems found by the previous group. Nevertheless, they showed to perceive and use the map in a different way, paralleling the modalities through which they commonly orient themselves in the world. Some participants (4 out of 8) counted on the map the elements they took as reference points in the real world: for instance, F3 enumerated the traffic circles and squares; instead, F8 and F7 searched for the bus stops without finding them (they are not signaled on the map). F2 reported to use the "images" of specific places (e.g., a fountain) to orient himself and wanted them on the map. Whereas F5 asked for the presence of cardinal points, as he was more at ease with "absolute" reference points. All these participants showed to have a very precise subjective representation of their city, made up of landmarks that they carefully memorized. These were sought even when navigating a digital map. Other participants (3 out of 8) said that the map contains too many elements (e.g., streets' names): it overwhelmed their senses making it difficult to focus on and find specific places. For this, after a brief interaction, they immediately used the search function. These participants explained that they find the same problems when using other map-based services: F4, for instance, says that "*It's very difficult for me to get out of all the elements on a map*."

Moreover, all the participants with autism expressed the desire of modifying the interface layout (especially the color of either the map or the navigation interface), as some elements were considered confounding or negatively affecting their perception. These whishes were idiosyncratic somehow reflecting their peculiar ways of perceiving the world. By contrast, the problems pointed out by neurotypical participants were far more homogeneous, and no one expressed the desire of changing the visual appearance of the interface to match her "preferences." Despite these problems, the majority of participants with autism (7 out of 8) favorably judged the possibility of finding "secure" places on a map.

Sensorial highlights. All the participants with autism read the sensorial highlights ascribed to the places inserted in the map. On the one hand, the sensorial highlights are considered particularly useful when something unexpected happens during transfers, so that they may need to quickly identify a "backup place" in the nearby to recover from anxiety. On the other hand, the textual reviews were perceived important especially when they need to figure out how a location looks like in advance: they allow them to identify the "details" of a place and to understand if they are suitable for them. Differently from other services like Google Maps, here the descriptions of places "*are specifically addressed to us, and they make it easy to understand whether there are places that we like, increasing our possibilities of moving to new places*" as F7 stressed, reporting a shared opinion (7 out of 8).

However, several participants with autism (2 out of 8) showed difficulties in understanding the point of view of other users when reading a textual review, being unable to put themselves in others' shoes. In other words, they focused on what a place meant for them (when they knew it) or how they would like it to be. Moreover, some of them (4 out of 8) did not understand the metaphors and the word games present in the textual reviews. This may suggest that we use more prominently "objective" indexes like numbers and scales to communicate the "nature" of a place beyond its six fundamental sensorial features. Two participants pointed out how these sensorial features should be contextualized with reference to the time in which they were recorded: F2, for instance, says that "*The temperature of an open place depends on the time and the season, if it's summer or winter, if it's day or night*", which may suggest that supplementary information should be provided, or that the value of the displayed features should be tied to the time of the reading.

Categorization. Categories, which had to be ascribed to the places inserted in the system, were perceived as understandable by the majority (14 out of 16) of the participants. Nonetheless, autistic participants (4 out of 8) specified that they were not exhaustive: participants "sliced the world" in more fine-grained categories, somehow reflecting the specialization of their interests. The possibility of adding tags, however, was considered an optimal remedy by the majority of participants with autism (5 out of 8) in order to increase the flexibility of the categorization and widen the semantic field of a place. This freedom, in participants' opinions, may maintain different perspectives on the same place, rather than forcing into a shared agreement: "*I like that we can define a place as we wan*t," F2 says. All the participants considered the filter function useful to select those places that could be interesting for them.

Crowdsourcing. The majority of the neurotypical (5 out of 8) and autistic participants (7 out of 8) expressed the willingness of participating to the population of the map, highlighting its utility also for touristic purposes. F4, for instance, stressed that she would happily contribute to review "Aspi friendly" places also outside the boundaries of her city. Nonetheless, neurotypical participants expressed some concerns about the motivations that could push themselves to contribute: S1 noticed that "*I think that the majority of the normal users should be motivated through some kinds of incentives*." This may point out the need to find motivational mechanisms encouraging users to populate the map.

Autistic participants encountered problems in inserting new entities in the system. They found it difficult to proceed and complete all the steps required for adding new places and defining their characteristics, as not all the form labels were perceived as clear, and some of the passages did not instruct them on the kind of information needed to be inserted. As a result, they became easily distracted and some of them decided to drop the insertion (2 out of 8). Likewise, neurotypical participants expressed the need to have clearer instructions on the kind of information to insert into the form fields: the place's textual review should be better structured, focusing on the specific aspects that could be relevant to the autistic population. Otherwise, "*places reviewed by autistic users and those inserted by others would give information of different value*," as noticed by S6, since the neurotypical reviews would not be able to provide descriptions significant in the autistic users' eyes. This may suggest that we define tools for allowing the active collaboration between neurotypical and autistic users in building reviews. This said, the insertion of subsequent entities was perceived as simpler showing that the system is easy to learn.

VI. Discussion

The study highlighted a variety of issues, especially for the autistic population, that should be fixed during the further development of the system.

In particular, a key finding of the study is that neurotypical and autistic users subjectively perceive and understand some features of the system differently. To account for the autistic experience, the interface, the map, and the form for inserting new places need to be cleared from those elements that may perceptually confound the user. Furthermore, the "record" of a place should include more "objective" values (e.g., numbers); likewise, the reviews could be better structured in order to underline the places' characteristics. Categories should also be narrowed to reflect the interests of people with autism. Neurotypical users should be further advised in how to write a review, focusing on details that could be relevant for the autistic population and avoiding word games and metaphors, which may not be understood by autistic individuals. Alternatively, users could be allowed to amend or integrate the reviews given by other users, as it is done in a wiki, to foster a tighter cooperation between neurotypical and autistic users.

An implication of this study, therefore, is that designers aiming to support the collaboration between autistic and neurotypical users need to account for the diversity of their subjective experiences, which may impact on their ways of interacting: visualizations and texts should be maintained as simple and clear as possible, minimizing the elements on the screen, as well as removing word games and figures of speech.

Despite these issues, this preliminary evaluation shows that the map satisfies, at least partially, the four user requirements we defined during the exploratory research and is acceptable and useful in the participants' eyes. First, the system map is understandable by users with autism and is useful to find information about places to visit (requirement 1). Second, the emphasis on the sensorial features of places, even though not sufficiently "objective," may support users in understanding what places to avoid and what to choose (requirement 2). Third, categories are a good solution for filtering out information that individuals with autism do not want to see, focusing them on places that mirror their interests (requirement 3). Finally, even if some incentives need to be introduced, participants stressed their willingness to map their city spaces through the system (requirement 4).

These requirements, as well as the way they have been satisfied, could inspire other researchers aiming to design "spatial services" addressed to the autistic population.

Across the themes identified it emerges a further user requirement connected with the users' subjective experience of the system: the need of personalization. All the participants with autism stressed that the implementation of some forms of personalization is needed, in order to meet their idiosyncrasies in terms of visualization and interaction modalities. For example, some participants had difficulties in visually distinguishing the entities on the map: for them, a personalized use of colors or icons to signal different categories of places could be introduced. Others, even though the system allows to visualize only the places linked to a specific "map unit" (e.g., the user's neighborhood), were overwhelmed by the number of elements displayed on the map: this may suggest that we propose "alternative views" on the map removing, rather than adding, elements (e.g., the names of the streets), in order to increase clarity and understandability. Another relevant point is related to the need of highlighting personalized landmarks allowing users to orient themselves on the map: some participants, for instance, searched for bus stops, as they do in real life, while others wished for "absolute" reference points.

Another key finding of this study, therefore, is that autistic individuals need highly personalized interfaces. This may imply that researchers aiming to design interfaces addressed to the autistic population provide tailored visualizations, or a multiplicity of functionalities so that each user can select what fits better her idiosyncratic needs.

A final point relates to the fact that participants seemed to seek their suitable places for a while when using the system. The usage of the data collected through crowdsourcing to provide personalized recommendations in real-time would allow them to easily find secure places when they are overwhelmed by anxiety [43]. To this aim we prototyped a hybrid recommender using a "cascade" approach [44]. The "cascade" recommendation is performed as a sequential process where each recommender refines the recommendations given by the previous one. We started with a content-based recommender [45] and then we filtered its results using a collaborative-filtering recommender [46]. The content-based recommender filters out the data on the basis of the user's preferences. These, at present, are explicitly given by the user during the first interaction with the system, by rating from 0 to 4 some "spatial categories" (e.g., parks, libraries) and providing their sensorial aversions. Then, for each of the preferred categories, we selected those items that i) have been rated positively by the user, or ii) are near to the user (within a range of 500 meters). Among such places, we selected those with sensory features that do not negatively affect her sensitivity, matching the crowdsourced data with the information given by the user.

Then, collaborative filtering using a user-to-user approach is employed for a more fine-grained selection. In traditional collaborative filtering process, the similarity among users depends on the users having rated similarly the same items. For people with autism, the items that they do not "like" are more important than those that they like, as the former may have severe consequences on their anxiety. Therefore, when calculating the similarity between two users, we considered not only their overall place ratings, but also their aversions (e.g., users that have aversion towards hot and narrow places are considered more similar than users that do not share the same aversions). Predictions on places to recommend are made using Pearson correlations. Preliminary assessment of prediction accuracy has been conducted by randomly simulating users and places' ratings. The tests conducted on 20% of the total number of places with a cross-fold validation scored 0.04 and 0.12 for Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE) metrics respectively.

VII. Limitations and Conclusion

A limitation of this work is that we did not evaluate the system in the field. To understand whether the system is able to generate engagement and assess whether people are willing to put efforts in populating the map, a long-term field trial is actually in need. However, at this stage, we wanted to explore how neurotypical users and users with autism perceive and understand our system, exploring their idiosyncratic subjective reactions, as well as assess whether it satisfied the requirements we defined. Before conducting an "in the wild" evaluation, we thought that it was essential to account for the diverse subjective experiences of the two populations. Another limitation is that the outcome of this work cannot be applied to mid- or low- functioning autistic users. We focused on persons with high-functioning autism because their everyday movements pointed to a more relevant need to use technological means for having spatial support. Further, they seem to be already accustomed to use digital services to cope with the uncertainty issues they may face in their everyday life. Persons with mid-functioning autism, instead, spend most of their time at home and do not have both the need and the desire of going outside. As future work, we aim to conduct a field evaluation of the system integrating the recommendation feature in order to investigate spontaneous processes of participation and test the recommendation algorithm.

As a conclusion, in this article we made three contributions. First, we defined the concept of "secure place" for autistic individuals: such places i) are known in advance, ii) present sensorial features that do not hurt the sensitivity of the person with autism, iii) mirror her interests. Second, we identified four user requirements for designing a technology support for the population with autism, as well as presented a map-based crowdsourcing system that may satisfy such requirements. These requirements may also inspire future research aiming to design "spatial services" addressed to autistic users. Third, we evaluated the system, pointing out the autistic people's idiosyncratic ways of interacting and their need of personalization: the study results may give researchers suggestions for designing interfaces for autistic users.

Acknowledgments

We want to thank the group of the Adult Autism Center of the city of Torino, and in particular Stefania Brighenti, Romina Castaldo, and Roberto Keller.

References

[1] P. Hobson, *Autism and the development of mind*. Psychology Press, 1995.
[2] A. E. Robertson and D. R. Simmons, "The Relationship between Sensory Sensitivity and Autistic Traits in the General Population," Journal of Autism and Developmental Disorder, vol. 43, no. 4, pp. 775-784, 2013.
[3] W. Simm, M. A. Ferrario, A. Gradinar, M. T. Smith, S. Forshaw, I. Smith, and J. Whittle, "Anxiety and Autism: Towards Personalized Digital Health," in *Proceedings of CHI '16*, 2016, pp. 1270-1281.
[4] J. Singer "Why can't you be normal for once in your life? From a 'problem with no name' to the emergence of a new category of difference," in Corker, M., French, S. (Eds.), *Disability discourse*. Open UP, Buckingham, pp. 59–67.
[5] C. Frauenberger, "Rethinking autism and technology," interactions, vol. 22, no. 2, pp. 57–59, 2015.
[6] C. Frauenberger, J. Good, and N. Pares, "Autism and Technology: Beyond Assistance & Intervention," in *Proc. Extended Abstr. Hum. Factors Comput. Syst.,* 2016, pp. 3373-3378.
[7] C. Frauenberger, J. Good, and W. Keay-Bright, "Phenomenology, a framework for participatory design," in *Proceedings of the 11th Biennial Participatory Design Conference (PDC '10)*, 2010, pp. 187-190.

[8] S. Gallagher and D. Zahavi. The phenomenological mind. New York, NY: Routledge, 2008.

[9] P. Dourish, *Where the Action is: The Foundations of Embodied Interaction*. MIT Press, 2001.

[10] A. Rapp, and M. Tirassa, “Know Thyself: A theory of the self for Personal Informatics,” *Human-Computer Interaction*, vol. 32, no. (5-6), pp. 335-380, 2017.

[11] K. Lynch, *The image of the city*. MIT Press, Cambridge, MA, 1960.

[12] S. Ramdoss, W. Machalicek, M. Rispoli, A. Mulloy, R. Lang, and M. O’Reilly, “Computer-based interventions to improve social and emotional skills in individuals with autism spectrum disorders: A systematic review,” *Dev. Neurorehabil.*, vol. 15, no. 2, pp. 119–135, 2012

[13] S. Boucenna, A. Narzisi, E. Tilmont, F. Muratori, G. Pioggia, D. Cohen, and M. Chetouani, “Interactive Technologies for Autistic Children: A Review,” *Cognitive Computation*, vol. 6, no.4, pp. 722-740, 2014.

[14] L. E. Boyd, A. Rangel, H. Tomimbang, A. Conejo-Toledo, K. Patel, M. Tentori, and G. R. Hayes, “SayWAT: Augmenting Face-to-Face Conversations for Adults with Autism,” in *in Proc. SIGCHI Conf. Hum. Factors Comput. Syst.*, 2016, pp. 4872-4883.

[15] A. D. Smith, “Spatial navigation in autism spectrum disorders: a critical review,” *Front. Psychol.*, vol. 6, no. 31, pp. 1–8, 2015.

[16] C. Cardonha, D. Gallo, P. Avegliano, R. Herrmann, F. Koch, and S. Borger, “A crowdsourcing platform for the construction of accessibility maps,” *in Proceedings of the 10th International Cross-Disciplinary Conference on Web Accessibility (W4A '13)*, 2013, Article 26, 4 pages.

[17] C. Prandi, P. Salomoni, S. Mirri, “mPASS: integrating people sensing and crowdsourcing to map urban accessibility,” in *Proceedings of IEEE 11th Consumer Communications and Networking Conference (CCNC)*, 2014, pp. 591-595.

[18] S. Carmien, M. Dawe, G. Fischer, A. Gorman, A. Kintsch, and J. F. Sullivan, “Socio-technical environments supporting people with cognitive disabilities using public transportation,” *ACM Trans. Comput.-Hum. Interact.*, vol. 12, no. 2, pp. 233-262.

[19] E. Bozgeyikli, A. Raij, S. Katkoori, and R. Dubey, “Locomotion in Virtual Reality for Individuals with Autism Spectrum Disorder,” in *Proc. of the 2016 Symposium on Spatial User Interaction (SUI '16)*, 2016, pp. 33-42.

[20] L. A. E. Boyd, X. Jiang, and G. R. Hayes, “ProCom: Designing and Evaluating a Mobile and Wearable System to Support Proximity Awareness for People with Autism,” in Proc. SIGCHI Conf. Hum. Factors Comput. Syst., 2017, pp. 2865-2877.

[21] P. L. Pearce and M. Fagence, “The legacy of Kevin Lynch: research implications,” *Annals Tour. Res.*, vol. 23, no. 3, pp. 576–598, 1996.

[22] D. Quercia, N. K. O'Hare, and H. Cramer, Aesthetic capital: what makes London look beautiful, quiet, and happy?,” in *Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing (CSCW '14)*, 2014, pp. 945-955.

[23] E. Morello and C. Ratti, “A digital image of the city: 3D isovists in Lynch's urban analysis,” *Environ. Plan. B: Urban Anal. City Sci.* vol. 36, no. 5, pp. 837–853.

[24] Y. Rogers and G. Marsden, “Does he take sugar?: moving beyond the rhetoric of compassion,” *interactions*, vol. 20, no. 4, pp. 48-57, 2013.

[25] A. Rapp, F. Cena, R. Castaldo, R., Keller, and M. Tirassa, “Designing technology for spatial needs: Routines, control and social competences of people with autism,” *Int. J. Hum-Comput. St.*, vol. 120, pp. 49-65.

[26] G.A. Bowen, “Naturalistic inquiry and the saturation concept: a research note,” *Qual. Res.*, vol. 8, no. 1, pp. 137–152, 2008.

[27] A., Zolyomi, A., A. Spencer Ross, A. Bhattacharya, L. Milne, and S. A. Munson, “Values, identity, and social translucence: neurodiverse student teams in higher education,” in *Proceedings of CHI '18*, 2018, Paper 499, 13 pages.

[28] D. Çorlu, Ş. Taşel, S. G. Turan, A. Gatos, A. E. Yantaç, “Involving autistics in user experience studies: a critical review,” in *Proceedings of the 2017 Conference on Designing Interactive Systems*, 2017, pp. 43–55.

[29] J. Saldaña. The coding manual for qualitative researchers, Thousand Oaks, CA: Sage, 2015.

[30] M. Winter-Messiers, “From tarantulas to toilet brushes: Understanding the special interest areas of children and youth with Asperger syndrome,” *Remedial and Special Education*, vol. 28, pp. 140-152, 2007.

[31] H. Hong, E. Gilbert, G. D. Abowd, and R. I. Arriaga, “In-group questions and out-group answers: crowdsourcing daily living advice for individuals with autism,” in Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems, 2015, pp. 777–786.

[32] C. Frauenberger, J. Makhaeva, K. Spiel. “Designing smart objects with autistic children: four design exposès,” in Proceedings of CHI ‘16, 2016, pp. 130–139.

[33] G. Boella, A. Calafiore, E. Grassi, A. Rapp, L. Sanasi, and C. Schifanella, “FirstLife: Combining Social Networking and VGIs to Create an Urban Coordination and Collaboration Platform,” *IEEE Access*, vol. 7, pp. 63230-63246, 2019.

[34] M. C. González, C. A. Hidalgo and A.-L., Barabási Understanding individual human mobility patterns. Nature vol. 453, pp. 779–782, 2008.

[35] I. Tsampoulatidis, D. Ververidis, P. Tsarchopoulos, S. Nikolopoulos, I. Kompatsiaris, and N. Komninos, “ImproveMyCity: an open source platform for direct citizen-government communication,” in Proc. 21st ACM international conference on Multimedia, 2013, pp. 839-842.

[36] A. Antonini, G. Boella, S. Buccoliero, L. Lupi, and C. Schifanella, “Foundations of Map-based Web Applications - A Survey of the Use, Limits and Opportunities Offered by Digital Maps,” in Proc. of VISIGRAPP (2: HUCAPP), 2017, pp. 92-99.

[37] A. Antonini, G. Boella, S. Buccoliero, L. Lupi and C. Schifanella, "Topology-aware indexing system for urban knowledge," 2017 IEEE Computing Conference, London, 2017, pp. 1003-1010.

[38] E. Wang, Y. Yang, J. Wu, W. Liu, and X. Wang. “An efficient prediction-based user recruitment for mobile crowdsensing,” IEEE Trans. Mob. Comput., vol. 17, no. 1, 16-28, 2018.

[39] Y. Yang, W. Liu, E. Wang, and J. Wu. “A Prediction-based User Selection Framework for Heterogeneous Mobile CrowdSensing,” IEEE Trans. Mobile Comput., vol. 18 , no. 11, 2460 - 2473, 1 2019

[40] W. Liu, Y. Yang, E. Wang, J. Wu. “Dynamic User Recruitment with Truthful Pricing for Mobile CrowdSensing,” In Proc. of IEEE International Conference on Computer Communications, 2020

[41] V. J. Hodge and J. Austin, “A Survey of Outlier Detection Methodologies,” *Artif. Intell. Rev.*, vol. 22, pp. 85–126, 2004.

[42] M. N. Marshall, “Sampling for qualitative research,” *Family Practice*, vol. 13, no. 6, pp. 522-525, 1996.

[43] F. Cena, A. Rapp, C. Mattutino, “Personalized Spatial Support for People with Autism Spectrum Disorder,” In Adjunct Publication of the 26th Conference on User Modeling, Adaptation and Personalization (UMAP '18), 2018, pp. 233-238.

[44] R. D. Burke. Hybrid recommender systems: Survey and experiments. In User Modeling and User-Adapted Interaction, Springer, 2002.

[45] M. J. Pazzani, D. Billsus. “Content-Based Recommendation Systems,” Springer, 2007.

[46] J. B. Schafer, D. Frankowski, J. Herlocker and S. Sen. “Collaborative Filtering Recommender Systems,” Springer, 2003.

Amon Rapp is an Assistant Professor with the Computer Science Department, University of Torino, Torino, Italy, where he leads the Smart Personal Technology Lab at ICxT. His scientific research is situated within the area of human–computer interaction.

Federica Cena is an Associate Professor with the Computer Science Department, University of Torino, Torino, Italy, where she is heading the Smart City Lab. She works on user modeling and personalization.

Claudio Schifanella is an Assistant Professor with the Computer Science Department, University of Torino, Torino, Italy, where he is a member of the Social Computing Research Group. His research interests include Urban Informatics and Decentralized Systems.

Guido Boella is a Full Professor with the Computer Science Department, University of Torino, Torino, Italy. His main research fields are geoinformatics, legal informatics, and blockchain technologies. He is the Coordinator of the CO3 EU project, the creator of FirstLife, and a co-founder of the spinoff Nomotica and the startup Sity.