Spatial Knowledge Acquisition from Addresses

Farid Karimipour[1], Negar Alinaghi[1,3], Paul Weiser[2], and Andrew U. Frank[3]

[1] Faculty of Surveying and Geospatial Engineering, University of Tehran, Iran
{fkarimipr, n.alinaghi}@ut.ac.ir

[2] Institute for Cartography and Geoinformation, ETHZ, Switzerland
pweiser@ethz.ch

[3] Institute for Geoinformation and Cartography, Technical University of Vienna, Austria
frank@geoinfo.tuwien.ac.at

Abstract. Addressing systems are primarily designed for enabling computers to match an address with its corresponding location on Earth. However, humans also frequently use addresses expressed in the form of addressing systems to find locations in the environment without any machine aid. In this paper, we discuss cognitive issues of addressing systems, by examining what types of spatial knowledge can be provided by Austrian, Japanese and Iranian addressing systems.

1 Introduction

An address is a specification that refers to a unique location on Earth [1]. It is usually expressed in the form of an addressing system, i.e. as a combination of certain components with addressing value (e.g. spatial features and their relations, postal codes, etc.). Addressing systems are primarily designed for enabling computers to match an address with its corresponding location on a map [1], a process called address matching or geocoding. However, people also use addresses expressed in the form of addressing systems to find locations in the environment without any machine aid. While there has been a considerable amount of research on evaluating [2-3] and improving [4-5] the accuracy of the geocoding process, the interaction of humans with addresses has been less explored.

An address is a spatial description composed of spatial relations between spatial features. It may thus be used to construct a spatial mental representation of the Geographic space to which it refers (cf. [6]). However, the type and extent of information that an address provides depends on its structure, which does in turn vary around the world.

In this paper, we explore cognitive issues of addressing systems, in particular the type of spatial knowledge they can provide for humans. We compare and analyze three different classes of addressing systems (Austria, Japan, and Iran) based on the types and relations of their addressing components.

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2 Spatial Knowledge Provided by Different Addressing Systems

Addresses usually contain a variety of elements that have addressing value, e.g. street name, crossing, building number, city sector, neighborhood, city, state, landmark, and postal code (cf. [2]). In the following, we elaborate on the Austrian, Japanese, and Iranian addressing systems as three classes of addressing with different structures and types of components, and discuss the spatial knowledge they can provide.

2.1 The Austrian Addressing System

Like most Western countries, the Austrian addressing system follows a strict structure; the order of elements as well as their writing style (e.g. punctuation) are fully standardized. Austrian addresses begin with the street name along with the house number. Building numbers are ordered along the street, with odd and even numbers on opposite sides (See Figure 1). If there are different units in one house, the unit (door) number comes after the house number (e.g., 27/**12**). In the case of having a block, an additional number stands between the house and the unit number (e.g., 27/**8**/12). Then follows the district number along with the city name. For example, *Gusshausstrasse 43/12, 1040 Wien* is an address expressed in this addressing system.

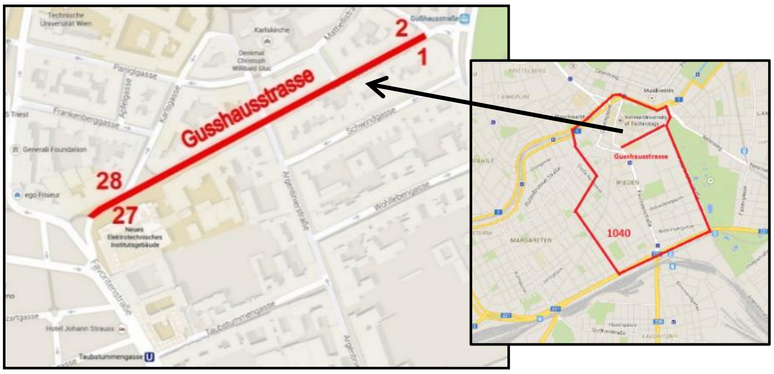

Fig. 1: The components of an Austrian address (Source: maps.google.com)

An Austrian address consists of a "containment" relation between street and district (street **S** is contained in district **D**). Moreover, the building number mentioned in the address has addressing value, because buildings are spatially ordered along the street, with odd and even numbers on opposite sides. In other words, an Austrian address provides information on the "district-street", "street-building", and "street side-building" relations. Putting this information together, someone interpreting an Austrian address may gain knowledge of its corresponding district and street, and can estimate the position and orientation of the target location in relation to the street. On the other hand, the Austrian addressing system can contribute to acquire spatial knowledge as it provides information about street-district relation. Nevertheless, a human needs to already know the street or at least the district in order to infer the location to some extent. In other words, one cannot have an image from the location to which an address refers, unless some of the spatial elements of the address already exist in one's spatial mental representation.

2.2 The Japanese Addressing System

Japanese addresses are based on a hierarchical subdivision named by alphabetical or numerical codes. An address begins with the largest and ends with the smallest subdivision level. The country is divided into 47 "*prefectures"* as the largest geographical subdivision. All prefectures have a "-ken" suffix, except for "Tokyo-to", "Kyoto-fu", "Osaka-fu", and "Hokkai-do", which have their own special suffixes.

Prefectures are divided into large towns, suffixed by "-shi". These large towns are themselves divided into small cities, suffixed by "-machi", or neighborhoods, suffixed by "-cho". In very large cities there may be an additional subdivision called "ward" with the suffix "-ku" between large towns and small cities/neighborhood. Small cities (machi) and neighborhoods (cho) are divided into numbered zones, suffixed by "-chome".

In contrast to many other countries, most streets in Japan do not have names; they are just empty spaces between blocks (See Figure 2). The blocks are numbered across each zone (chome), which are suffixed by "-ban" in new parts and by "-banchi" in old parts of the cities. At the lowest level, houses on a block are numbered with the suffix "-go". The order of house numbering is based on the date the houses were constructed, which leads to houses that are not spatially ordered within a given block. An (optional) apartment number often comes after the building number (e.g. 5-**103**-go). For example, *Hokkaido, Sapporo-shi, Teine-ku, Maeda-machi, 10-Chome, 2-banchi, 8-25-go* is an address expressed in the Japanese addressing system. Most of the above suffixes can be dropped; there are also several alternatives to combine the house and building numbers, which are syntactical issues and beyond the scope of this paper.

A Japanese address reveals the containment relations between prefectures, large towns (shi), cities (ward), and small cities/neighborhoods (machi/cho). However, this is not the case for zones (chome), blocks (ban or banchi) and building numbers (go), because they restart from 1 at each upper subdivision (for example, each zone has blocks #1, #2, #3, ...), and thus are less spatially informative. Since building numbers are temporally-ordered, they provide no information about the spatial relation between the buildings. In other words, the Japanese addressing system consists of different levels of spatial elements up to small cities/neighborhood (i.e. prefecture, shi, ward, and machi/cho). However, the zones, blocks, and building numbers repeat at each upper subdivision, and thus allow for less spatial inference. Upon reaching the subdivision level n, one has to search for the subdivision level n+1 on one's own, as the address has no information about the spatial relations between the subdivisions. In other words, if one has been to, say, block 14, one may not necessarily be able to infer the location of block 15. Even if one knows the block, one cannot imagine where the building number is located unless one has been there before, finds it on the map, or has access to other forms of spatial information. This may be one reason for Japanese business cards typically having small maps of the area printed on the back to indicate the location of the address. This spatially-nonconsecutive code-based addressing seems not to be very compatible with human spatial thinking. Once a block is known, one can remember where it is, but its relation to other blocks and relations between the buildings of the block are not necessarily added to spatial knowledge due to the nonconsecutive numbering.

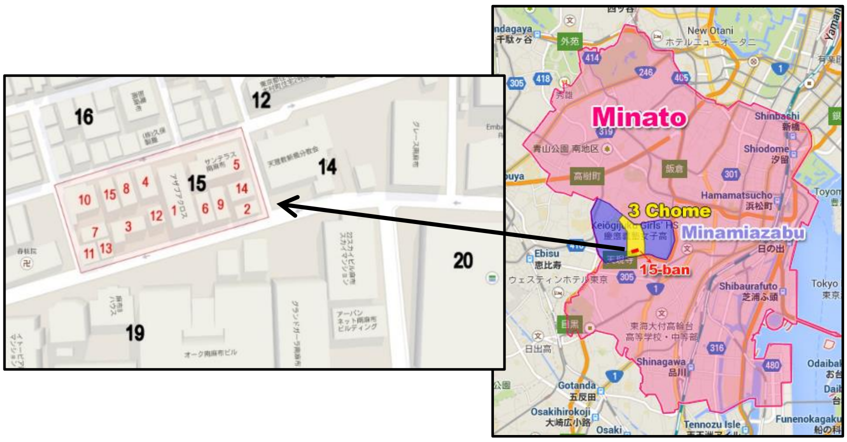

Fig. 2: The components of a Japanese address. Notice there are no street names for the streets, only blocks are numbered. The buildings of block #15 were manually numbered by the authors (Source: maps.google.com)

2.3 The Iranian Addressing System

In Iran, street names are not unique, and thus additional procedural information is needed to make a unique reference. Thus, people in Iran express addresses as a sequence of spatial features (e.g. streets, squares, landmarks), and their spatial relations (e.g. 100m *after*, a few steps *before*, *in front of*) starting from a known element. Any addressing concept (street, junctions, landmarks, etc.) may be considered to have addressing value and thus be used in the address. For example, in Figure 3 the address of point **A** based on route #1 is "*Shariati Ave., Gholhak, Pabarja St., Ayeneh Blvd., West corner of Gol-e-yakh Alley, No. 2, Unit 9*". “*Shariati Ave.*” may be omitted if the receiver already knows *Gholhak*. Alternatively, “*After Zafar St.*” may be added after “*Shariati Ave.*” to provide a less familiar receiver with some estimation on the part of the long “*Shariati ave.*”. Even worse, the same place could be equally referred to in completely different ways because different starting points or spatial elements may be used [7]. For example, based on route #2 in Figure 3, point **A** is referred to as "*Shahrzad Blvd., Pabarja St., Ayeneh Blvd., West corner of Gol-e-yakh Alley, No. 2, Unit 9*".

The Iranian addressing system expresses an address in the form of a route description which requires a unique starting point known to the receiver. If such a point is not initially known it has to be established interactively through a negotiation process (cf. [8]). Iranian addresses describe spatial relations between a set of spatial features. The relations could be quantitative (e.g. 100*m*) or qualitative (e.g. in the middle of); and the spatial features could be anything with addressing value, ranging from streets and crossings to city sectors, neighborhoods, landmarks, buildings etc. Moreover, as in Austria, the building numbers are spatially ordered along the street, with odd and even numbers on opposite sides. This combination is a process that provides the users with the position of the target location. In addition, the Iranian addresses are a set of spatial groups, each of which provides information about spatial features or relations. This addressing system frequently exposes the agent to the spatial features of the environment as well as their spatial relations. We suppose, they contribute considerably to the acquisition of spatial knowledge.

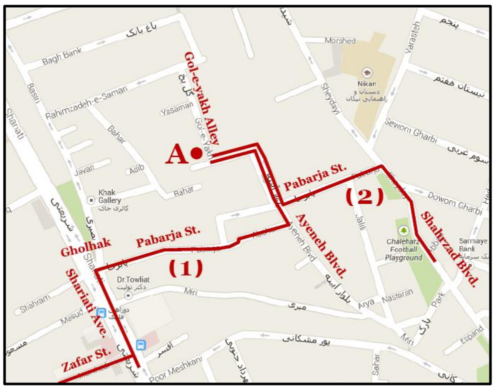

Fig. 3: The case of Iran: Location **A** is referred to in three equally valid ways using different starting points and spatial elements (Source: maps.google.com)

A distinct characteristic of the Iranian addressing system is its flexibility: addresses could be any number and order of expressions as long as they obey the rule of spatial groups. The starting point and the level of detail provided in the address are flexible, and depend on the current location as well as the spatial knowledge of the agent. The address can be changed in a way that the two parties can go to a level of detail that is comprehensible (based on their knowledge about the environment, their spatial abilities, etc.) for both sides (cf. [8]). This flexibility may also provide an opportunity for better place learning. As Golledge and Stimson [9] argued, place learning "is a cognitive process guided by spatial relationships rather than by reinforced movement sequence. …there are clear implications that places are learned, that possible connections between them are built up over time, and that individuals develop a capacity for linking previously unknown [locations]… by referring to a general spatial schema that incorporates concepts of [spatial relations]". An Iranian address flexibly provides various movements to reach a certain location, rather than a fixed movement sequence.

3 Discussion and Future Research Directions

Studying different addressing systems can lead to a better understanding of the way different people around the world think about space. A Japanese person who has been exposed to an addressing system with no names for streets, but (temporally-ordered) codes for blocks and buildings may conceptualize space differently than an Iranian person who has been interacting with a route-description-based addressing system full of spatial elements as well as metric and topological relations. We believe this has considerable effect on different aspects related to spatial thinking, such as route planning, as well as verbal and non-verbal spatial communication. What we presented in this paper are the initial results of our ongoing research on the semantics and pragmatics of different addressing systems. Based on our initial analysis we pose two hypothesis:

1. Addresses have an impact on how people conceptualize Geographic space. Procedural addresses (like Iran) allow humans to acquire more detailed mental representations of the geographic space to which the address refers.

2. The way people conceptualize Geographic space is biased towards the type of the addressing system to which one has primarily been exposed.

The above mentioned hypotheses need to be refined and tested in future empirical work. We are collecting the required empirical information for the first hypothesis through questionnaires. We also intend to test the second hypothesis through doing experiments with Iranians that are exposed to Austrian addresses, and vice versa.

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