SoftwareX 7 (2018) 138–142

Contents lists available at ScienceDirect

SoftwareX

journal homepage: www.elsevier.com/locate/softx

Original software publication

IASM: Individualized activity space modeler

Kamyar Hasanzadeh

Department of Built environment, Aalto University, PO Box 14100, 00076 Aalto, Finland

A R T I C L E I N F O

Article history:
Received 10 January 2018
Received in revised form 16 April 2018
Accepted 20 April 2018

Keywords:
Activity space
Neighborhood
GIS
Place exposure

A B S T R A C T

Researchers from various disciplines have long been interested in analyzing and describing human mobility patterns. Activity space (AS), defined as an area encapsulating daily human mobility and activities, has been at the center of this interest. However, given the applied nature of research in this field and the complexity that advanced geographical modeling can pose to its users, the proposed models remain simplistic and inaccurate in many cases. Individualized Activity Space Modeler (IASM) is a geographic information system (GIS) toolbox, written in Python programming language using ESRI's Arcpy module, comprising four tools aiming to facilitate the use of advanced activity space models in empirical research. IASM provides individual-based and context-sensitive tools to estimate home range distances, delineate activity spaces, and model place exposures using individualized geographical data. In this paper, we describe the design and functionality of IASM, and provide an example of how it performs on a spatial dataset collected through an online map-based survey.

Code metadata

Current code version	*V 2.0.1*
Permanent link to code/repository used of this code version	https://github.com/ElsevierSoftwareX/SOFTX_2018_35
Legal Code License	*MIT*
Code versioning system used	*none*
Software code languages, tools, and services used	*Python, Arcpy*
Compilation requirements, operating environments & dependencies	*Requires Arcpy module installation*
If available Link to developer documentation/manual	https://github.com/kamyar68/-IASM/blob/master/Instructions%20and%20Tutorial/Instructions.pdf
Support email for questions	kamyar.hasanzadeh@gmail.com

1. Motivation and significance

Researchers coming from different disciplines have long been interested in analyzing and describing human mobility patterns. Understanding human mobility behavior has been especially important in social sciences, as well as in health geography, and environmental health promotion research. Therefore, an ample amount of research has focused on assessing the human exposure to different environmental characteristics to find empirical evidence of their associations with health and wellbeing [1–5].

Although some studies have been able to verify the importance of urban environment on people's lived experiences [6–8], the results from prior research on the environment–health relationship has often revealed marginal influence of environmental factors [9–13]. Researchers increasingly attribute the weakness of the observed associations to the misspecification of the geographical context [4,14–16]. In these studies, it is crucial to have a precise understanding of not only the extents of the geographical context, but also individuals' exposure to the places and their characteristics [17–19].

The growing literature from diverse fields such as public health, health geography, transportation, urban planning, and environmental psychology has brought along different terms for referring to similar concepts related to human activities and mobility in space. These terms include, but are not limited to, activity space [20], local activity space [19], home range [21], territorial range [22], action space [23], home zone [24], and neighborhood [18]. In this companion paper, we use the terms activity space and home range.

Activity space (AS) can be defined as a union of spaces where individuals are in direct contact with as a result of their mobility behavior and daily activities. As it can be implied from this definition, AS is usually deemed as an unrestrained part of the environment, whereas the home range involves a higher focus on

E-mail address: kamyar.hasanzadeh@aalto.fi.

https://doi.org/10.1016/j.softx.2018.04.005

the areas around an individual's place of residence [19]. Therefore, a home range –also known as a local activity space – can be regarded as a subarea of the whole AS which is often restrained by a locality or home range threshold [19]. Accordingly, while both concepts can be referred to using the more inclusive term AS, home range is sometimes used to underline the geographical scale and focus of a model.

ASs have been applied in a diversity of fields to describe the extents of mobility [25,26] or to identify places that people are exposed to [15,27]. However, despite the relatively broad application of ASs, their measurement has not been very advanced either conceptually or technically. That is why most of the efforts to this point are often limited to creating over-simplistic boundaries of these spaces. Buffers of different sizes [13], minimum convex polygons [28], standard deviational ellipses [29], and dynamic home ranges [30], are examples of such so-called *container* approaches [19]. However, some research show that ASs may be more than mere boundaries. Hasanzadeh and his colleagues [19] use a notion of place exposure and argue that not only exposure varies from one person to another in its spatial extents, but also can vary from place to place in its magnitude. The Individualized Residential Exposure Model (IREM) introduced by these researchers is based on the understanding that place exposure is an integral part of ASs and therefore should be part of the modeling.

Although the application of such advanced models have shown to improve the empirical findings, their use has remained limited in research. This can largely be due to the current complications of using geographical information systems (GIS) in this line of research. A geographic information system (GIS) is a framework for gathering, managing, and analyzing spatial data. The readily available GIS tools at this point, do not provide an easy way of implementing many of the discussed concepts related to the modeling of ASs. Moreover, many researchers who are potentially interested in use of such methods do not come from a spatial sciences background and may not have the required expertise to implement such ideas. The software described in this document is motivated by these complications and it aims to provide convenient tools that can support and promote use of more advanced AS models in research.

Individualized Activity Space Modeler (IASM), is a GIS toolbox providing tools for modeling, visualizing, and describing individual ASs. The first tool, Home range distance identifier, uses a mathematical algorithm to estimate an optimal distance for defining home ranges [30]. The second tool, home range modeler, creates an individualized and parametric model of home range boundaries [30]. The third tool, IREModeler, is an implementation of IREM [19]. This tool is an extended version of the home range modeler which not only estimates the extents of AS, but also models the variation of place exposures within the defined boundaries. Finally, the fourth tool provides a new method of modeling AS boundaries incorporating place exposure. The maximum exposure area estimator, identifies and extracts high exposure areas using a minimum exposure value defined by the user.

In this document, the tools' functionalities are demonstrated using data collected from more than 800 participants through an online map-based survey (public participation GIS). However, in order to provide a more focused image of what the toolbox creates, results from an individual randomly selected from the participants is presented in this paper. It is worth noting that the toolbox is also compatible with geographic data collected through other methods such as GPS and mobile phone tracking.

2. Software description

This software is made of four independent, yet closely related and complementing, GIS tools, which carry out specialized tasks for modeling ASs of individuals. The AS models in this toolbox are created using information on participants' home locations, activity points, and optionally travel routes and modes. The tools are developed in Python language using ESRI's Arcpy module and thus, are compatible with ESRI file formats. The modeling tools in this toolbox have the capability of modeling ASs of many individuals in a single run through an implemented iterative process.

2.1. Software architecture

In the following sections, we will provide the overall architecture and implementation details for each of the four tools in this toolbox.

2.1.1. Home range distance identifier

This tool uses distances from activity points to the individual home locations to provide an estimation of the home range distance. This is done through an implementation of Jenk's optimization method, designed to determine the best arrangement of values into different classes [30]. The algorithm seeks to minimize each class's mean deviation from the class average, while maximizing each group's deviation from the means of the other classes [31]. The optimum number of classes in this tool is identified using the Goodness of Variance Fit (GVF), while making sure that the chosen break distance includes at least 80% of activity points.

This approach has been previously implemented in empirical research [30]. More details on the theoretical aspect of the model can be found in the cited paper.

2.1.2. Home range modeler

This tool creates customized convex polygons for each individual using three parameters, D1, D2, and D3. D1 is the circular buffer distance representing the immediate neighborhood of an individual. The default value taken from literature is 500 m [30], however, this can be modified by the user. D2 is the distance used to create circular buffers around visited points. This is meant to represent an estimated area of exposure around each activity point and to take the fuzzy characteristic of ASs into consideration [4]. This value can be determined either by measuring the average size of spatial clusters in the dataset [30], or by calculating the average block sizes in the study area. However, these are some practical suggestions and the user can define this value using other applicable criteria. Finally, D3 is a threshold for defining the home ranges. In other words, if applied, any point beyond this distance will be left out of modeling. D3 can be either systematically defined using the Home range distance identifier tool described above, or by using other criteria defined by the user.

This model has been previously implemented in empirical research [30]. More details on the theoretical aspect of the model can be found in the cited paper.

2.1.3. IREModeler

This is an extended version of the Home range modeler described above, which creates a more spatially sensitive model of ASs using a notion of place exposure. In the first step, the spatial delimitation of the AS is defined using an integrated piece of code from Home range modeler tool. In the second step, the place exposures are estimated using home and activity points, frequencies or duration of visit, travel mode, and travel routes. To quantify the level of exposure, weights are assigned to each spatial feature. The weights for point features are calculated in terms of frequency or total time of visit per a defined duration. Accordingly, the highest weight is allocated to home points as the location people typically frequent on a daily basis or spend most of their time in. Depending on the frequency or duration of visit indicated for each visited point, weights are allocated to each of them. A weight for each