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A new anthropocentric approach in accessibility analysis: the activity space and the accessibility measures

Moustou Fotini[a]

[a]*Municipality of Karditsa, 18th August 12 ,43100 karditsa, Greeece*

Abstract

This study aims to examine individual accessibility experiences in space and time, through developing a new composite accessibility measure using spatial, temporal and travel data. According to time-geography, all the activities have spatial extent and temporal dimensions and they are unseparated. So, the proposed measure is influenced not only by usual factors such as the places of activities and the travel time, but also by the factors of individual activity space and the temporal constraints. Activity space represents the spatial movement as part of a human daily experience. The suggested accessibility measure lays the foundations of this relationship of accessibility measures and the activity space. Both the proposed individual composite accessibility measure and the factor of activity space are applied in the city of Volos, using the university students' daily diaries. The GIS functions contribute significantly to the application and the evaluation of the relationship of the accessibility measures and the activity space. To sum up, the creation of a composite accessibility measure in individual level is very important in the field of spatial mobility planning, because it is an indicator of quality of life, and it is a useful measure of the social and spatial equity to urban services.

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Corresponding author. E-mail address: moufotini@yahoo.gr

1. Introduction

Accessibility is an important factor for addressing spatial problems such as urban isolation and degradation, environmental and traffic problems and social exclusion. Accessibility affects positively to the efficient allocation of services and the location's decisions of different users in the city. Accessibility has been defined in several different ways (Hansen, 1959; Hägerstrand, 1970; Ingram, 1971; Dalvi and Martin, 1976; Burn, 1979; Ben-Akiva and Lerman, 1979; Morris, et al. 1979 ;Tagore and Sikdar, 1995; Geurs, van Wee , 2004). According to Geurs and Van Wee (2004) the components that make up the concept of accessibility are the land use, transport, temporal constraints and the person-individual.

The variety of definitions and applications of accessibility led to different spatial levels of analysis. In particular, the accessibility analysis started with the accessibility at zonal level. The zonal accessibility analysis has the disadvantage of being influenced negatively by the size and the form of the zones, and by the data aggregation. For this reason, the accessibility analysis in zonal level was considered a relatively insufficient way of presentation of accessibility and thus the accessibility analysis in individual level was imported (Ben - Akiva and Lerman, 1979;

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Kwan, 1998; Kwan, 1999; Kwan and Weber, 2008). This paper develops a new accessibility measure in individual level.

The incorporation of the individual activity space in an accessibility measure imposes the effect of the daily spatial movement of a human, which shows the individual's perception of accessibility (Golledge and Stimson, 1987). In the literature, the activity space has many different formulations (Sherman, et al. 2005; Buiiung, Kanaroglou, 2006; Manaugh, El-Geneidy, 2012). In the present research, the notion of activity space is incorporated in the proposed accessibility measure and the individual activity spaces are generated by the daily individual diaries.

Furthermore, the temporal constraint is incorporated in the suggested individual accessibility measure. According to van Wee and Geurs (2011), temporal constraint is a very important element in determining accessibility. Temporal constraints in relation with spatial factors were studied in the fields of transportation and geography (Ettema et al., 2007; Kwan, 1998, 1999; Kwan and Weber 2003, 2008; Neutens, 2010; van Wee and Geurs, 2011). So, the proposed composite individual accessibility measure is influenced not only by usual factors such as the places of activities and the travel time, but also by the factors of individual activity space and the temporal constraints.

The suggested approach is applied to a certain social team in the city of Volos, Greece. Two types of data are required for the determination of the suggested measure. Firstly, activity diary data, which are collected by interviewing Students University and stored as point entity in GIS maps. Secondly, road network data (polyline entity) are used.

This article is composed of four units. In the second unit, it is presented the scientific framework of the proposed accessibility measure and the activity space index. In the third unit, it is implemented the suggested equations of the new composite accessibility measure and the activity space index. In the fourth unit, conclusions are presented.

2. The proposed anthropocentric approach in accessibility analysis

2.1. Activity space and accessibility

The activity-space was developed in the 1960s and 1970s and it was representing the spatial movement as part of a human daily experience and thus experience of place. Activity space is described as a measure of the degree of individual mobility, incorporating constraints, needs and travel options. This experience of place shows the relationship of distance and dispersal of individual activities as the individual's perception of accessibility (Golledge and Stimson, 1987). The research of spatio-temporal geography uses ideas and methods that resemble activity space. Kwan's ‘‘daily potential path area’’ is used to measure individual access to urban opportunities (Sherman et al., 2005). Activity space is revealed by a growing need of the importance of non-commuting trips to the total travel of households (Buliung, Kanaroglou, 2006).

With recent advances in GIS technology and through the increasing availability of spatially referenced data, activity space has become a more attractive tool for studying the spatial behavior of individuals. Same technological advances have enabled researchers to develop new measures of activity space (Rai, et al. 2006). According to Sherman, et al. (2005) activity space has been formulated as a standard deviational ellipse (SDE), a road network buffer and a polygon of standard or relative travel. Furthermore, Buiiung and Kanaroglou (2006) introduced the convex hull polygons to operationalize activity space (Manaugh, El-Geneidy, 2012). Schönfelder and Axhausen (2005) suggested the shortest-path network or kernel-density as the formulation of the activity space. Botte and Olaru (2010) examined new geometries of activity spaces such as super ellipses, Cassini ovals, and bean curves.

The geometry, size and structure of activity spaces are determined by mainly three determinants (Golledge and Stimson, 1997; Schönfelder and Axhausen, 2002):

- The position of travellers’ home location
- Activities: (Mobility to and from frequently visited activity locations such as work or school)
- Movements between the centres of daily life travel

Activity spaces can be generated by a variety of sources (interviews, travel diaries, locations of members of one’s formal or informal social network) (Schonfelder , Axhausen, 2003; Axhausen, 2007; Harding, 2013).

Past studies showed that higher values of accessibility are connected with smaller activity spaces. Smaller activity spaces associate with less detrimental travel behaviour, such as decreases in VKT and increases in active mode shares