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Research paper

Exploring trajectories and tourist behavior using the entropy curve

Explorando trayectorias y desplazamientos turísticos usando curva de entropía.

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ABSTRACT

The purpose of this study is to develop a new method that allows calculating the characteristics of tourist paths, favoring the understanding of visitor behavior. Changes and complexities are considered between a first phase of quasi-random "search" of attractions and tourist sites to visit, and a second phase of direct access to places of interest in the territory. This method is based on the notion of entropy curve, where a low value corresponds to a direct and rapid access to the preselected or recently defined sites, and a high value corresponds to an almost random search for tourist sites showing a more erratic behavior of the tourist. The location in space and time of the high entropy parts of the tourist trajectory would allow making better decisions related to the management of tourism in a given territory.

Keywords: *Trajectories, tourist behaviors, entropy curve, tourism management, decisions.*

RESUMEN

El propósito de este estudio es desarrollar un nuevo método que permita calcular las características de los desplazamientos turísticos, favoreciendo la comprensión del comportamiento del visitante. Se consideran cambios y complejidades entre una primera fase de "búsqueda" cuasi-aleatoria de atractivos y sitios turísticos a visitar, y una segunda fase de acceso directo a lugares de interés del territorio. Este método se basa en la noción de curva de entropía, donde un valor bajo corresponde a un acceso directo y rápido a los sitios preseleccionados o recientemente definidos, y un valor alto corresponde a una búsqueda casi aleatoria de sitios turísticos que muestran un comportamiento más errático de los sitios turísticos. La ubicación en el espacio y el tiempo de las partes de alta entropía de la trayectoria turística permitiría tomar mejores decisiones relacionadas con la gestión del turismo en un territorio determinado.

Palabras clave: Modelos de desarrollo, experiencias turísticas, patrimonio, desierto de Atacama.

INTRODUCTION

The management of tourist activity is increasingly related to the use of the information that we can obtain to improve decision-making. In this sense, technologies have been an important element in the improvements that can be incorporated in the tourism industry and in the experiences that tourists can live in the territory (Cegur, 2019). Properly understanding the way in which tourists move will allow a good management of tourism in cities and in the different geographical spaces in which it takes place (Xu, 2021). Likewise, tourist experiences could be planned aiming to increase their satisfaction through the arrangement of spaces, the delivery of information and the selection of activities to offer, based on the tastes and motivations that they have, which could be seen evidenced in the recommendations that tourists make of a visited destination (Bayih & Singh, 2020), which in the long run will impact on subsequent visitor flows. Taking as a basis the importance of tourist information for the management of the offer and the territorial ordering, a method based on the entropy curve is proposed that allows evaluating the visitor's behavior based on the data obtained from the GPS installed in the mobile devices of people on the move in the Atacama region, Chile. Georeferencing technology provides important data on the spatial-temporal relationship of the tourist (Zheng, 2019), emphasizing the trajectories that the tourist carries out and their implication in an adequate management of the territory's offer.

It is clear the importance of understanding the movements and circulation of tourists (Xu et al. 2021), for which it is necessary then to propose new methods, which provide new perspectives to compare with the results that have already been obtained by various previous studies. With this knowledge it is possible to make improvements in the management of tourism in the destinations where it is developed, allowing new commercial strategies to be implemented, better territorial regulations and also improving the visitor experience.

LITERATURE REVIWED

The way in which tourists make decisions about the places they visit or what they consume cannot be analyzed with conventional theories and in the long run it becomes necessary to look for new analysis alternatives (Smallman & Moore, 2010). Most of the studies point, among others, to the tourist's motivation as that which leads them to decide what they will consume (Kotler & Make, 2014), and on which they will make a subsequent decision to return and establish themselves as loyal customers. tourism products or services (Lee, 2009). However, there are studies that show that this motivation-behavior relationship is not always direct (Bayih & Singh, 2020), where the motivations would affect the resulting satisfaction but not necessarily the behavior, even returning to the destination without recommending it. From the point of view of the usual tourists of a destination, they tend to be less affected by the stimuli or commercial actions derived from competitiveness (Alegre & Juaneda 2006), and many of the tourists who repeated destinations were based on previous experience dedicating less time to plan or search for information (Li, Cheng, Kim & Petric, 2008). Incorporating the geographic-spatial variable, the behavior of the tourist has been analyzed in multiple studies addressing different spatial scales between destinations and tourist attractions (Gu et al., 2021), determining that there are supply and demand factors influencing the movements of tourists, and the long influencing the planning of your itineraries. The evaluation that was made previously about the behavior of the tourist was based mainly on direct observations of the tourists and interviews, however the problem with this is the possibility of error or manipulation by the interviewee (Grinberger, Shoval, & McKercher, 2014) because in the long run there may be differences between the records and reality, due to the human factor present. This is then added to what various studies indicate about the connection that occurs between the economic management of tourism, psychology as a commercial work tool and tourist trips (Wang & Miller, 2014).

Tourism technologies have generated important changes in the business models of the industry (Cheng & Zhang, 2017), among which aspects such as distribution and intermediation stand out, which have also had an impact on what Kotler and Make (2014) point out as the motivations with which the tourist will decide what he consumes. In this same sense, some of the barriers that technologies have been able to break (Vu, Li, Law & Ye 2015) are related to the cost and time reduction of traditional data capture methods, and on the other hand to the incorporation of preferences in the behavior of tourists. GPS technology has made it possible to understand the movement of tourists in an effective way, contributing to the understanding of their mobility (Lazer et al, 2009), however a greater number of studies are still necessary to quantify the behavior patterns of tourists (Xu, Xue, Park & Yue, 2021) or in comparing the general trajectories of tourist movements using different methods (Zheng et al, 2019) for this purpose. It is therefore necessary to search for alternatives and new methods for analyzing the behavior of tourists in the territory, in this sense, the use of mobile devices has contributed significantly in areas such as stays, consumption of activities, among others, but still the data are scattered and isolated (Xu et al, 2021) in terms of identification of displacement patterns. Some important data are, for example, what Wang et al. (2018) regarding the analysis of studies carried out on the use of mobile devices, where frequent travelers would be more in favor of using mobile technology. There are a large number of methods for analyzing data and tourism trajectories. According to the study by Zheng et al. (2019) the results of their method (D&E) allow us to understand the trajectories in order to improve decision-making and tourism management in the territory. This is relevant to the extent that the more methods that allow measuring and comparing behaviors and trajectories, the better the tourist's understanding will be and therefore the more possibilities there will be to improve local tourism.

METHODOLOGY

Theoretical tools

The notion of curve entropy has been invented by the French mathematician Michel Mendès-France (Mendès-France, 1983) and further adapted to the quantification of the complexity of animal or human "foraging" trajectories. The first application is related to the foraging curves of rodents (Bovet & Benhamou, 1988; Dicke & Burrough, 1988; Bovet & Benhamou, 1991). The second is related to human trajectories like the climbing curves of alpinists (Cordier, Mendès-France, Bolon, & Pailhous, 1994). It is clear that a tourist trajectory, like an alpinist or rodent trajectory, has several phases, one first irregular corresponding to learning the environment with a high entropy, and a second showing portions more linear corresponding to reaching precise touristic goals discovered after consulting human or book/internet guides.

By trying to quantify these different phases, we have proposed the Mendès-France curve entropy adapted to calculate the complexity of a trajectory between two times t1 and t2 and to compare different periods in the time evolution of this entropy.

Definition of the curve entropy

M. Mendès-France proposed the following definition of curve entropy (Mendès-France, 1983): let consider the curve of length (t) taken from the origin point M(0) until the point M(t) reached at time t by a tourist (Fig. 1). ∂K(t) being the perimeter of the smallest convex set containing the curve of length (t), the Mendès-France curve entropy at time t, denoted H(t), is defined by:

$$H(t) = \log2[2\square(t)/ \partial K(t)]$$

For calculating easily the curve entropy, an estimation of ∂K(t) can be obtained by determining the external and internal quantities EP(t) and IP(t), calculated as perimeters of polygonal lines containing the trajectory between 0 and t, and then, by calculating the mean of these two values:

$$\partial K(t) \approx [EP(t) + IP(t)]/2.$$

The external polygon is obtained by tracing the most external tangents to (t), starting from M(0) and ending to M(t) and completing if necessary by the segment M(0)-M(t). The internal polygon by tracing the most internal tangents to (t), starting from M(0) and ending to M(t) and completing if necessary by segments of the external polygon (see Fig. 1).

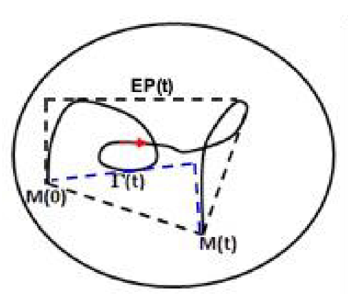


Fig. 1. Definition of the Mendès-France curve entropy.

After this first definition, M.M. Dodson and M. Mendès-France have proposed some sophisticated versions of curve entropies (Dodson & Mendès-France, 2013), but the simple definition above is well adapted to the tourist problem. We can for example use this notion for quantifying the curve complexity in some theoretical examples, corresponding to a straight line and to a periodic line (Fig. 2):

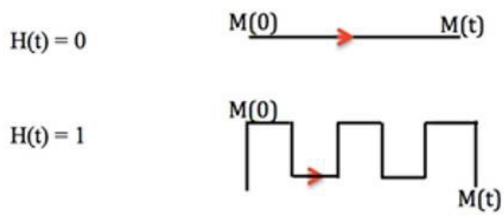


Fig. 2. Theoretical examples of curve entropy calculations for a straight line (top) and a periodic curve (bottom)

Data acquisition

To acquire tourist trajectories, it is necessary to use the GPS of the vehicles used at the different phases of his exploration. The data have to be incorporated on the same collection of maps (Fig. 3) and the geographic or personal annotations come from the general knowledge about sites to visit and from the specific information given by the tourist along his sojourn (the so-called travel diary or "journal de bord").

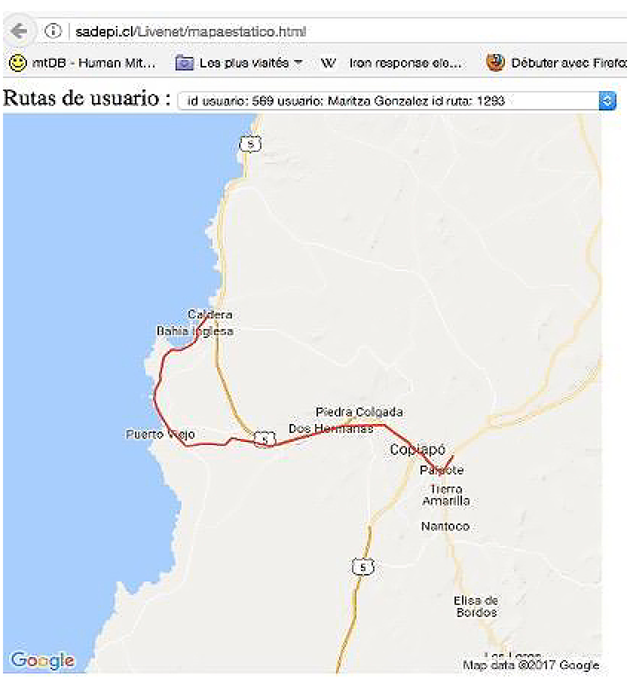
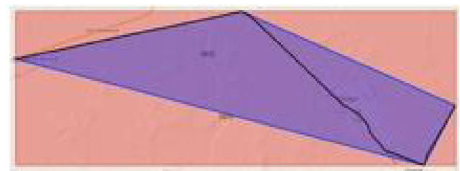


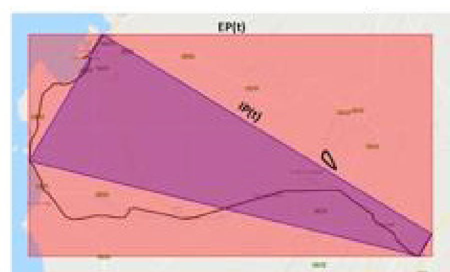
Fig. 3. GPS data acquired from the tourist vehicles and reported on a digitized map (here from Google maps® facilities)

RESULTS

The different tourist trajectories are belonging to three types of behaviors with increasing complexity and total entropy going from near 0 to near 5.



ENTROPY	0.06
Complete trajectory distance	43.14 km.
EP(t)	88.52 km.
IP(t)	76.99 km.

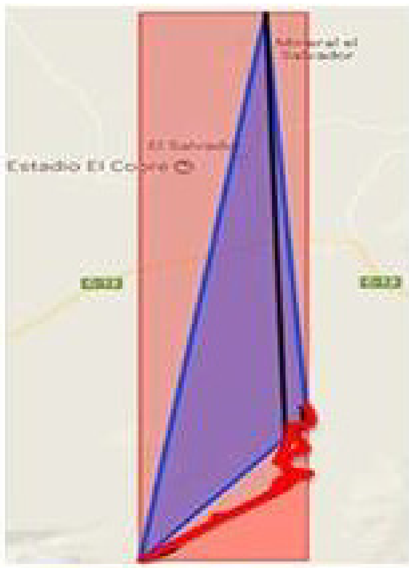


Entropy	0.41
Complete trajectory distance	115.32 km.
EP(t)	182.19 km.
IP(t)	166.13 km.

Fig. 4. Calculation of the curve entropy for trajectories of type 1. The trajectory bottom corresponds to the data of Fig. 3.

A trajectory of the first type has a total entropy less than 0.5 and corresponds to a tourist having pre-planned his visits and going directly to the different touristic targets in a predefined order (Fig. 4).

The second type corresponds to a complexity diminishing from a first phase of exploration to a second phase of decision (Fig. 5). The entropy decreases between the two phases and the total entropy (from 0 to t) is close to 1. For this second type, it is necessary to distinguish well the two phases, and then, to calculate the curve entropy between times 0 and t and to choose as frontier between the two phases the time at which the value of the local entropy E(t) (calculated between 0 and t) starts to decrease (Fig. 6).



Entropy	0.92
Complete trajectory distance	27.76 km.
EP(t)	20.70 km.
IP(t)	37.96 km.

Fig. 5. Tourist trajectory of type 2 and calculation of its entropy. First phase of exploration (in red), Second phase of decision to visit the El Salvador mine (in black).

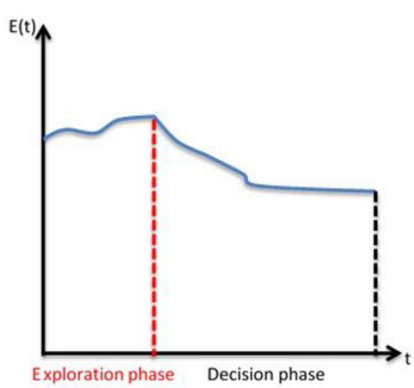


Fig. 6. The two consecutive Exploration and Decision phases determined by following thetime evolution of the local curve entropy E(t). The frontier corresponds to the first diminution of E(t) not followed by an increase of E(t).

The third type corresponds to trajectories having a curve entropy between 3 and 5, decreasing from the first phase of exploration to the second of decision (Fig. 6), during which the different touristic targets have not been ordered in a rational way. In total absence of touristic strategy, the implementation of the local tactic by the tourist seems chaotic (Fig. 7).

Entropy	4.66
Complete trajectory distance	2001.50 km.
EP(t)	113.25 km.
IP(t)	203.67 km.

Fig. 7. Calculation of the entropy for a trajectory of type 3

DISCUSSION

The objective of this study was to identify behavioral profiles based on the trajectories of visitors, aiming to contribute to the management that could be done on the territory in aspects such as the ordering of the offer and visitor assistance. The results of the study show that there are two important phases in the behavior of tourists in their movements through the territory. A first phase of exploration where tourists travel more distance and space to reach their attractions or places of interest. The second phase is where tourists have already made a decision and therefore the travel time in the territory is less and the distance they will travel is less. The information obtained allows more appropriate decisions to be made in aspects such as the commercialization of tourist experiences and services scattered throughout the territory, clearly pointing out commercial actions to tourists who arrive for the first time, differentiating them from those who have already come before. In this way, the relationship that can occur between the local offer and the visitor can be more efficient in definitions such as what is the most appropriate information to deliver, at what time or in what place. This can be a benefit for public actors as well as for local companies and entrepreneurs. The calculation of the complexity characteristics of the search path of a tourist allows the personalization of the information, even in real time if the tourist agrees to communicate their GPS coordinates during their trip. In addition, by providing your personalized information, knowing your position in the region will allow you to anticipate dangerous situations in the most complex areas of the territory (such as the desert), anticipating risk situations or making rescue or emergency evaluation more effective.

CONCLUSIONS

The understanding of tourist trajectories and their application in a large number of areas has been raised in different investigations, highlighting their importance, however the need for more studies and methods (Zheng, 2019) that can be applied has also been evident. By obtaining new methods of analysis of trajectories, patterns and profiles of behavior can be obtained that in the long run will allow to carry out more precise actions when managing territories such as tourist destinations, places of interest, large areas with little offer, among other areas. Technology at the service of tourism management is important at a time when most visitors use mobile devices both in pre-trip activities and on the trip itself and once they have returned home.

In the analysis of the trajectories with the entropy curve, it was possible to establish that there are two behavior profiles in the movements that tourists make through the territory, one that acts in an erratic or random way in their search for attractions and places of interest, and a second profile that acts in a more direct way when traveling, shortening the selection times for their trip in the territory. With this information, decisions about how to equip access places with tourist information could be improved, being able to guide the displacements towards the sites that it is intended to promote with the tourist's visit. In addition, information on services and attractions related to each other could be presented, improving the experience that the tourist will have. Finally, it would be important to carry out future research seeking to compare the results produced by this method of the entropy curve with others reviewed in the literature and that incorporate GPS and mobile devices for the understanding of trajectories at the service of tourism management.

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REFERENCES

Alegre, J.,C. Juaneda (2006) Destination Loyalty: Consumers' Economic Behavior. Annals of Tourism Research 33, 684–706.

Bayih, B.E., Singh, A. (2020). Modeling domestic tourism: motivations, satisfaction and tourist behavioral intentions. Heliyon, 6 (9)

Bovet, P., & Benhamou, S. (1991). Optimal sinuosity in central place foraging movements. Animal Behavior, 42, 57-62.

Cegur, T. (2019). 01The role of information technology in tourist information.

Cheng, W. y Zhang, Y. (2017). Research on the impact of tourism development on regional ecological environment and countermeasure based on big data. Boletin Tecnico/Technical Bulletin. 55(7). 464-470.

Cordier, P., Mendès-France, M., Bolon, P., & Pailhous, J. (1994). Thermodynamic study of motor behaviour optimization. Acta Biotheoretica, 42, 187-201.

Dicke, M., & Burrough, P. A. (1988). Using fractal dimensions for characterizing tortuosity of animal trails. Physiological Entomology, 13, 393-398.

Dodson, M. M., & Mendès-France, M. (2013). About entropy of curves. Journal of Integer Sequences, 16, 2-8.

Grinberger, A. Y., Shoval, N., & McKercher, B. (2014). Typologies of tourists' time–space consumption: A new approach using GPS data and GIS tools. Tourism Geographies, 16 (1), 105–123.

Gu Q., Zhang H., Huang S., Zheng F., Chen Ch. (2021) Tourists' spatiotemporal behaviors in an emerging wine region: A time-geography perspective. Journal of Destination Marketing & Management, 19.

Kotler, Bowen, Make, (2014). Marketing for Hospitality and Tourism. Pearson Education Limited, USA.

Lazer, D., Pentland, A., Adamic, L., Aral, S., Barabási, A. L., Brewer, D., et al. (2009). Computational social science. Science, 323, 721–723.

Lee, T.H., (2009). A structural model to examine how destination image, attitude, and motivation affect the future behavior of tourists. Leisure Sci. 31 (3), 215–236.

Li, X., C. Cheng, H. Kim, J. F. Petrick (2008). A Systematic Comparison of First-Time and Repeat Visitors via a Two-Phase Online Survey. Tourism Management 29, 278–293.

Mendès-France, M. (1983). Chaotic Curves. In M. Cosnard, J. Demongeot & A. Le Breton (Eds), Rhythms in biology and other fields of applications (pp. 344-357), Berlin: Springer Lecture Notes in Biomaths 49.

Smallman, .C y Moore, K. (2010). Process studies of tourist decisions-making. Annals of tourism research, 37(2), 397-422.

Vu H.Q., Li G., Law R., Ye B.H. (2015). Exploring the travel behaviors of inbound tourists to hong kong using geotagged photos. Tourism Managment. 46, 222-232

Wang, D., Park, S., Fesenmaier, DR. (2012). The Role of Smartphones in Mediating the Touristic Experience. Journal of Travel Research. 51(4), 371-387. doi:10.1177/0047287511426341

Wang, J., & Miller, E. J. (2014). A prism-based and gap-based approach to shopping location choice. Environment and Planning B: Planning and Design, 41(6), 977–1005. https://doi.org/10.1068/b130063p.

Xu, Y., Xue, J., Park, S., Yue, Y., (2021) Towards a multidimensional view of tourist mobility patterns in cities: A mobile phone data perspective. Computers, Environment and urban systems. 86. https://doi.org/10.1016/j.compenvurbsys.2020.101593

Zheng, W., Zhoub, R., Zhangc, Z., Zhongb, Y., Wanga, S., Weia, Z., Jia, H., (2019) Understanding the tourist mobility using GPS: How similar are the tourists?. Tourism management. 71, 54-66. https://doi.org/10.1016/j.tourman.2018.09.019