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Analysis of Spatial Concentration of Accommodation Establishments Using Machine Learning Techniques and Spatial Analysis Tools

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Abstract:

Tourism as an economic activity is influenced by social dynamics that can be measured by spatial analysis processes where phenomena such as concentration, trajectory and extension are evidenced, which can guide policy makers effectively for decision-making. In this document, the results of a study of spatial analysis of the concentration of accommodation establishments in the department of Boyacá, Colombia are presented in order to identify the correlation that exists between the territorial concentration, the natural attractions of the department and the type of establishment. It was found that there is evidence of a strong concentration in five clusters associated with three municipalities of the department's offer, however it is observed that statistically there is a high level of dispersion of the establishments explained by the road corridors and a growing development towards the natural attractions which are not fully covered by the current offer.

Keywords: economical clustering; GIS; tourism concentration.

JEL Classification: O30; C38; Z32.

Introduction

Activities associated with tourism, frequently generate positive externalities that allow territories to create favorable long-term development dynamics in which the challenge is to ensure their sustainability. One strategy is the agglomeration of tourist services based on criteria such as tourist attractions, which can be natural, cultural, social and endogenous; these generate the attraction of visitors who demand diverse tourist services such as accommodation, recreation, gastronomy, transportation, among others. However, the accommodation service in this ecosystem of services is a strategic reference to determine the dynamics of agglomeration due to its stability and physical existence and from it the others that develop around it can be analyzed in order to make strategic decisions in associations, government and local communities (De Siano & Canale 2022; Ma *et al.* 2022; Wang & Chen 2022). In Colombia, the tourist administration of the department of Boyacá has a special interest in determining the degree of tourist agglomeration present in its territory in order to identify special areas of

organizational intervention, as well as to measure the impacts of this economic activity on local dynamics within order to establish the region's tourist capacities and predictively evaluate possible behaviors in order to anticipate potential future impacts.

This document describes the process to perform a spatial concentration analysis using independent techniques based on machine learning and spatial statistical analysis tools, in order to establish a system of recommendations that allows focusing the efforts of the departmental public administration (Kang *et al.* 2022). The problem is initially described by analyzing the local antecedents and the consumer profile of the tourist services in the regions, as well as a theoretical description of the agglomeration processes in tourism and their spatial concentration. Subsequently, theoretical aspects of the statistical techniques to be used in concentration analysis are described and then three types of results are presented; The first is a general analysis of the location of the establishments and their typology, secondly, the intrinsic spatial concentration based on the agglomeration detected with the identified and georeferenced establishments is analyzed, and finally a correlational analysis is presented between the agglomeration and the tourist attractions prioritized naturals.

1 Problem Statement

1.1 Problem Background

The World Tourism Organization defines tourism as those socio-economic activities that involve the displacement of individuals beyond their usual environment for reasons of pleasure or business (World Tourism Organization, 2021). In this way, tourism involves all those actions in which a tourist expense is incurred. One of them is, of course, the tourist accommodation service, the reason for this study. Regarding the role of tourism in economic growth, its particular importance in the department of Boyacá should be highlighted, consolidating itself during the years 2000 to 2017 as the most influential actor in the region (Triviño 2020). While in the same period, sectors which have historically boosted GDP, such as livestock, mining and industry contributed between 5.58% and 20.86% to growth, the contribution of the tourism sector ranged between 19.28% and 22.95% (Avella *et al.* 2019).

1.2 Agglomeration as an Economic Phenomenon

Agglomeration occurs when there is, in a specific place, a large number of establishments in the same sector and their economic activities are similar (Manrique 2006). Therefore, economic agglomerations are the existing markets in a given space where supply is too high (Manrique 2006). To study these agglomerations and determine their economic impact, different cluster models are used, such as the Marshall model, used to determine companies whose innovative capacity depends on the flexibility of their services; the model called Hub – and – Spoke, used to determine local companies that are in untapped market niches, but that are part of a location status, and the Satellite Platform model, used to determine new companies with the help of the presence of trained personnel in each region (Álvarez *et al.* 2006). The agglomerations generate a new trend called spatial economy in which the regions are part of a process of implementing a culture of improvement and of being more attractive to the eye in order to incorporate sales and purchase relationships of services (Ruiz 2015). This causes metropolitan expansion, that is, an expansion in the markets generating a growing production of goods and services. Also, it encourages foreign trade from an economic competitiveness and creates external economies by increasing spatial interaction and economies of location (Trullén 2002). It is important to mention that the more agglomerations there are, the more companies will appear creating business nuclei (Martí & Muñoz 2009) and these companies, by being part of the agglomerations, begin to make changes in the economic structure, productive organization, technological systems, business relationships, actors, social structure, information systems, market structure and forms of competition (Garofoli 1995).

Currently, in Colombia there are different processes to strengthen agglomerations to create and achieve to balance a spatial structure of wages and lower the high costs in transport (Villegas 2009). This is why these processes have reached different sectors such as in the tourism sector because they are important for the economy of the regions as it increases interconnectivity and integration through tourism networks, competitive relationships and cooperation between actors of the destinations. In addition, it promotes the development of purchasing products and regional tourism (Hua & Wondirad 2021). Also, an increase in investments that are in favor of economic growth are beginning to be witnessed, generating economies that favor and intensify the capital of products and services (Semerena & Olmos 2005) generating conditions for the development of potential for companies, supporting micro-enterprises in the region (Alem 2006) and highlighting its influence on national development processes (Walle 2017).

1.3 Tourism and Spatial Concentration

The relationship between the economic growth of a region and the concentration of the tourism industry in it is widely documented. Zhou and Cao (2010) have shown that industrial clustering in China's Jiangsu province is positively related to greater economic development in the region; On the other hand, Lanlan and Quiang (2017) have specifically analyzed the agglomeration of the tourist industry and Chinese economic growth, proving that there is a spillover effect of agglomeration on regional economic growth. This spillover effect can be explained in part by the increase in productivity due to the clustering of tourism. Yoo, Williams, Park and Chen (Kim *et al.* 2020) have discovered the existence of a direct effect between the tourist agglomeration and the improvement of the productivity rates in the United Kingdom, the researchers found that the spatial proximity between tourist companies allows an increase of knowledge and skills in companies in the same region and the consequent increase in productivity. Associated with the same agglomeration phenomenon, there is also an increase in knowledge, availability of labor, technologies and skills, as a result of the interaction between nearby hotels, which explains the added productivity observed in the regions studied by Qiangyuan, Xinhua and Tzung -Cheng (Qiangyuan *et al.* 2021). In this way, the tourist agglomeration becomes a tool to take into account in order to increase the development of a specific region or as a method for the desired economic reactivation in the post-pandemic scenario. Regarding the latter, the researchers Kaushal and Srivastava (2020) have highlighted some ideas, the result of surveys carried out with CEOs of the main hotels in India, that can help to face the challenges of the current situation. For those surveyed, emphasis should be placed, among others, on strengthening the skills and knowledge of employees to promote their contractual continuity and reduction of layoffs, as well as the adoption of new technologies that increase productivity and biosafety; results that can be achieved through spatial tourist concentration processes as mentioned.

2 Materials and Methods

2.1 Tourist Variables of the Accommodations to Review

The tourism variables that will be studied in this research were obtained from databases of the Colombian Tourist Information Center (Citur) and recognized by the literature, which are presented below:

Table 4. Tourism Variables

Variables	Description
Density	This variable was found with the number of hotels in each municipality over the area in km2 of each municipality.
Offer	The 1,033 hotels registered in the CITUR databases, plus the 441 hotels mapped using the Google Maps tool, remain in this variable.
Natural Attraction	In this variable are the natural attractions by municipalities of the department that present clusters of hotels around them.
Category	This variable includes accommodation and lodging establishments that are: Hostels, Aparthotels, Tourist Apartment, Camp, Vacation Center, Tourist Farms (Rural Accommodation), Hostel, Hotel, Other Types of Non-Permanent Tourist Accommodation, Other Types of Tourist Housing and Shelter.

The offer is defined as a quantity measured in the number of hotels per city, being an indicator that shows the capacity that a city has to support the arrival of tourists. Depending on this, the density is presented that allows the generation of an indicator of agglomeration since it indicates the degree of intensity with which the hotel offer is presented in a given area. In this sense it is a reliable indicator of concentration. The natural attraction understood as mountains, lagoons and snow-capped mountains was defined as a key variable of the characterization, since it transcends several cities that are the focus of tourism and is an attractive element of tourists, so it can be assumed that it generates a concentration of hotels around them. Finally, the hotel category is a variable that allows to visualize the way in which the different types of accommodation are distributed in Boyacá.

2.2 Agglomeration and Clustering Analysis Methods

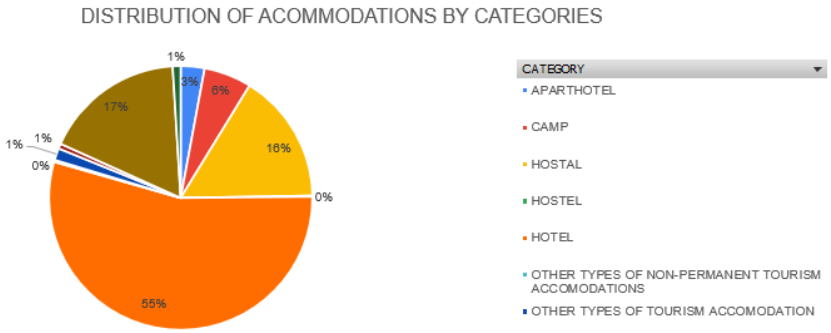
The agglomeration / clustering methods are based on the calculation of the distances between the elements of the study data set; Usually, these data are gathered within a matrix, so that the identification of the existing distances between each element is easier. After having this matrix, the elements with similar distances are searched and grouped into sub-matrices. In this way, the elements are grouped in conglomerates until all the

elements are in a single group. Based on the above, you need to specify a grouping method and criteria to find the proximal distance such as the mean distance or the weighted mean. Clustering methods are diverse and vary according to the required application. The most commonly used are Ward's method, Average Nearest Neighbor (Mitchell 2005) and Supervised learning (UniMOOC, 2021).

3 Results

3.1 Classification by Category

Figure 3. Classification by category of accommodation.

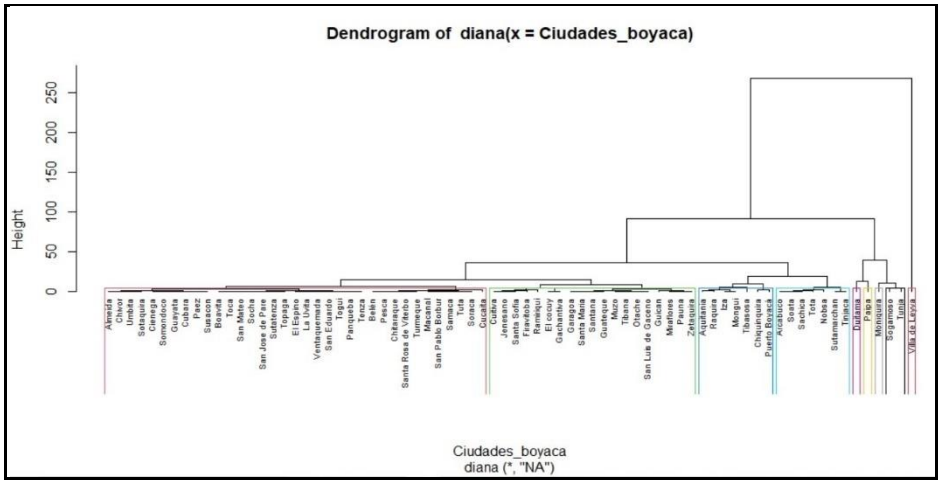


As can be seen in the circular diagram, and the map, most of the accommodations in the Boyacá region are hotels, followed by hostels and tourist farms (rural accommodation), this indicates a stable offer oriented towards traditional accommodation focused on the offer of rooms for periods of time where the tourist raises their tourism needs on their own or by tour operators. Establishments with tourism activity such as hostels, camps and holiday centers are complementary to the department's accommodation offer.

3.2 Density According to the Current Supply

Using the statistical programming language R, a hierarchical clustering algorithm was used using Ward's method based on the variables Number of Hotels per city and hotel density, where hotel density refers to the number of hotels in the city area in square kilometers in a city, thus obtaining, for a total number of clusters equal to 5, the following dendrogram:

Figure 4. Clusters dendrogram by hotel density and city



As can be seen, the concentration of establishments has two typical behaviors. The first behavior in the first cluster is explained by the natural attractiveness of the municipality. In clusters 2, 3, 4 and 5 there are concentrations between different municipalities that share common access roads, local attractions where the tourist attraction generates common groups. The last cluster is an extended area that groups the remaining non-agglomerated municipalities.

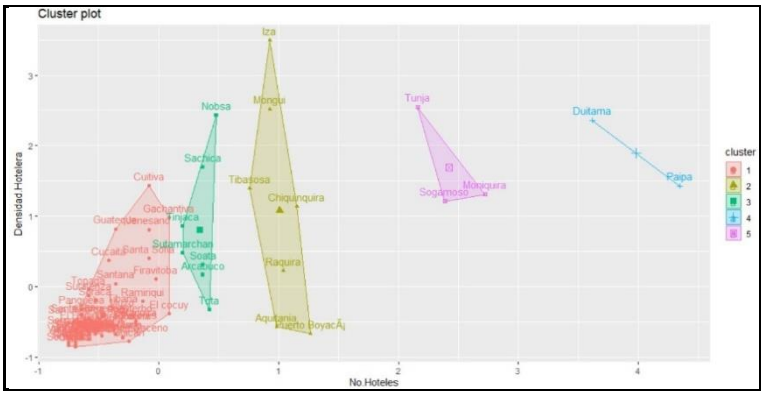
In this sense, it can be observed that the diversified hotel concentration of Boyacá in the defined municipalities can be clearly classified into 5 specific clusters, in red, those with a lower capacity, in blue the cities of Duitama and Paipa with a high capacity, clearly Villa de Leyva as a very specific case of tourism with a very high level of tourist capacity.

Table 5. Hotel concentration by Municipality

Cluster	Municipalities	Quantity	% concentration of total
1	Villa de Leyva	269	20.39%
2	Duitama, Paipa	171	12.96 %
3	Tunja, Sogamoso, Moniquirá	173	13.11%
4	Iza, Monguí, Tibasosa, Chiquinquirá, Ráquira, Aquitania, Puerto Boyacá	277	21%
5	Nobsa, Sáchica, Tinjacá, Sutamarchán, Soatá, Arcabuco, Tota	144	10.91%
6	Almeida, Belén, Boavita, Chitaraque, Chivor, and others	335	25.39%

Subsequently, the city of Villa de Leyva was removed, in order to create a cluster with a higher level of specific visibility, obtaining the following clustering map:

Figure 5. Diagram Ward Method - Hotel Density (Zoom-Excludes Villa de Leyva)



After clustering using Ward's algorithm, a graphic cluster was made based on the number of hotels, obtaining the following clustering map:

Figure 6. Clustering map by grouping of points using Qgis

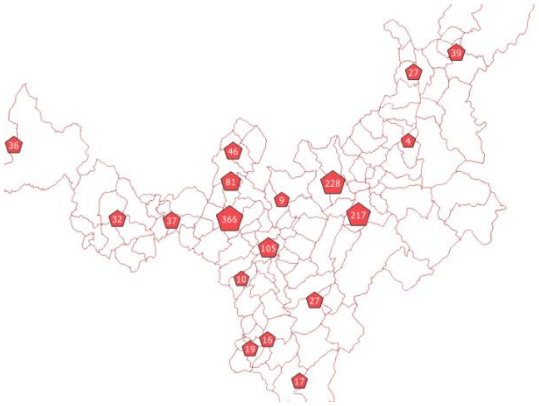
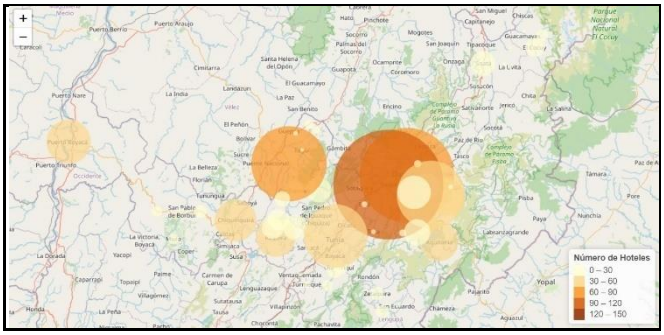


Figure 7. Map of hotel density based on the number of hotels per city using RStudio



In addition, the cities with the highest hotel concentration were described using a dynamic cartogram through RStudio, with which it could be observed that Villa de Leyva, Paipa and Duitama have a higher hotel concentration in terms of supply.

3.3 Density According to the Tourism Attraction

Natural tourist attractions were identified and prioritized based on the department's tourist vocation. These are:

Table 6. Location by Tourism Attractive

Attraction	Latitude	Longitude	Extension
Laguna de Tota	5.55	-72.93	60 km2
Parque el Cocuy	6.51	-72.19	3.060 km2
Museo Villa de Leyva	5.63	-73.52	N/A
Laguna del Alto	5.94	-72.99	0.0068 km2
Parque Pisba	5.89	-72.57	450 km2
Puente de Boyacá	5.45	-73.43	N/A
Termales de Paipa	5.76	-73.11	N/A

These tourist attractions were defined based on what was observed in the Boyacá Tourist Information System (SITUR). According to SITUR, these attractions are among the main ones in Boyacá, which is why they were defined as the study points for the analysis of density by attractiveness, since according to what has been studied in the literature, the existence of a agglomeration of tourism depending on the attractions that the areas can offer. In addition to Lake Tota as a high potential tourist attraction in the region, the Cocuy Park was found within the SITUR database. Located near the municipality with the same name (although it covers a wide geographical region), it is a tourist site par excellence having in itself the famous snowy mountain that bears the same name. Additionally, confirming the density and agglomeration results of the previous images, the Villa de Leyva Museum had the highest result in terms of agglomeration, being seen in the largest circle of all.It can also be seen that both the Boyacá Bridge and the Paipa Hot Springs have a high number of hotels; finally, there are the Laguna del Alto and El Parque Pisba with a low hotel density even though they are relevant tourist attractions.

In addition, certain clusters were defined graphically considering the fact that some of them are located around attractions or tourist centers and not exclusively cities, as was the case of Lake Tota, which covers a considerable number of municipalities in its entirety, within which are Tota, Aquitania and Llano de Alarcón, as can be seen:

Figure 8. Hotel concentration map according to tourist attractions using Argis

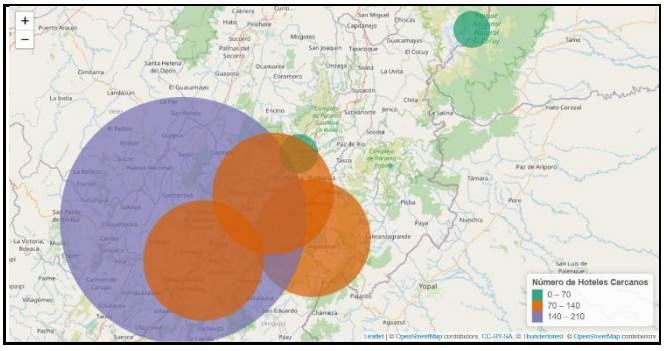


Table 7. Concentration by Tourism Attractive

Tourism Attractive	Surrounding Municipalities	Number of hotels	Concentration
Parque el Cocuy	El Cocuy, Panqueba, Guican	31	5.38%
Laguna de Tota	Tota, Aquitania, Iza	98	17.01%
Museo de Villa de Leyva	Villa de Leyva	207	35.93%
Laguna el Alto	Belén, Santa Rosa de Viterbo, Duitama (Zona Sirata)	33	5.72%
Parque Pisba	Socha	4	0.69%
Puente de Boyacá	Jenesano, Ramiriquí, Tibaná, Turmequé, Ventaquemada, Samacá, Tunja	101	17.53%
Termales de Paipa	Paipa, Tuta	102	17.7%

3.4 Analysis of Nearest Neighbors Algorithm Application

Using the software QGIS, and its tool "Analysis of Nearest Neighbors" out of the spatial database, the next results were obtained:

- Observed mean distance: 443.99833010827
- Expected mean distance: 0.03232991264
- Nearest neighbour index: 13733.36003153266
- Number of points: 1319
- Z-Score: 954110.03090270795

According to the results obtained through the application of the mentioned algorithm there seems to be some kind of scattering in the map because of the result of the Nearest neighbour index, however, it could be potentially as a consequence of the existence of variables such as extension and trajectory.

Conclusions

According to the results obtained, a relationship can be made with previous studies of spatial analysis where it is evidenced as tourist attractions (Parque el Cocuy, Laguna de Tota, Museo Villa de Leyva, Laguna del Alto, Parque Pisba, Puente de Boyacá and Termales de Paipa) in rural areas produce a great demand from tourist consumers. This generates in the department of Boyacá a growth of accommodation, forming a new economic geography that allows three important aspects such as territorial expansion, foreign and domestic trade, and external and internal economies.

Similarly, the Hotspots analysis shows that the agglomerations of establishments are mainly present in 5 provinces, namely: Ricaurte, Centro, Occidente, Tundama and Sugamuxi. This phenomenon reinforces the conclusions about the existence of a positive relationship between economic growth, productivity and agglomeration, obtained by previously cited studies(Lanlan & Qiang 2017; B. Zhou *et al.* 2016; H. Zhou & Cao 2010) given that, according to a 2019 analysis (Avella *et al.* 2019)municipalities belonging to these provinces, above all, are the ones that have contributed the most to the department's economic growth. Specifically, Tunja and Sogamoso, belonging to the Centro and Sugamuxi provinces, respectively, contributed 26.1% to the departmental GDP; while the weight of Villa de Leyva and Moniquirá (Ricaurte province) in the same was 2.2%, a lower percentage than the previous one, but above the average of municipalities without tourist agglomerations. Likewise, Paipa and Duitama (Tundama province) added 11.2%; Tibasosa and Nobsa (Sugamuxi province), 8.9%, and Chiquinquirá (Occidente province) added 3.9%. According to these results, in relation to the agglomerations found in the municipalities, each one of them must participate in the construction of programs that improve relationships, technological systems, information systems and social structures and allow the growth of tourism in the department.

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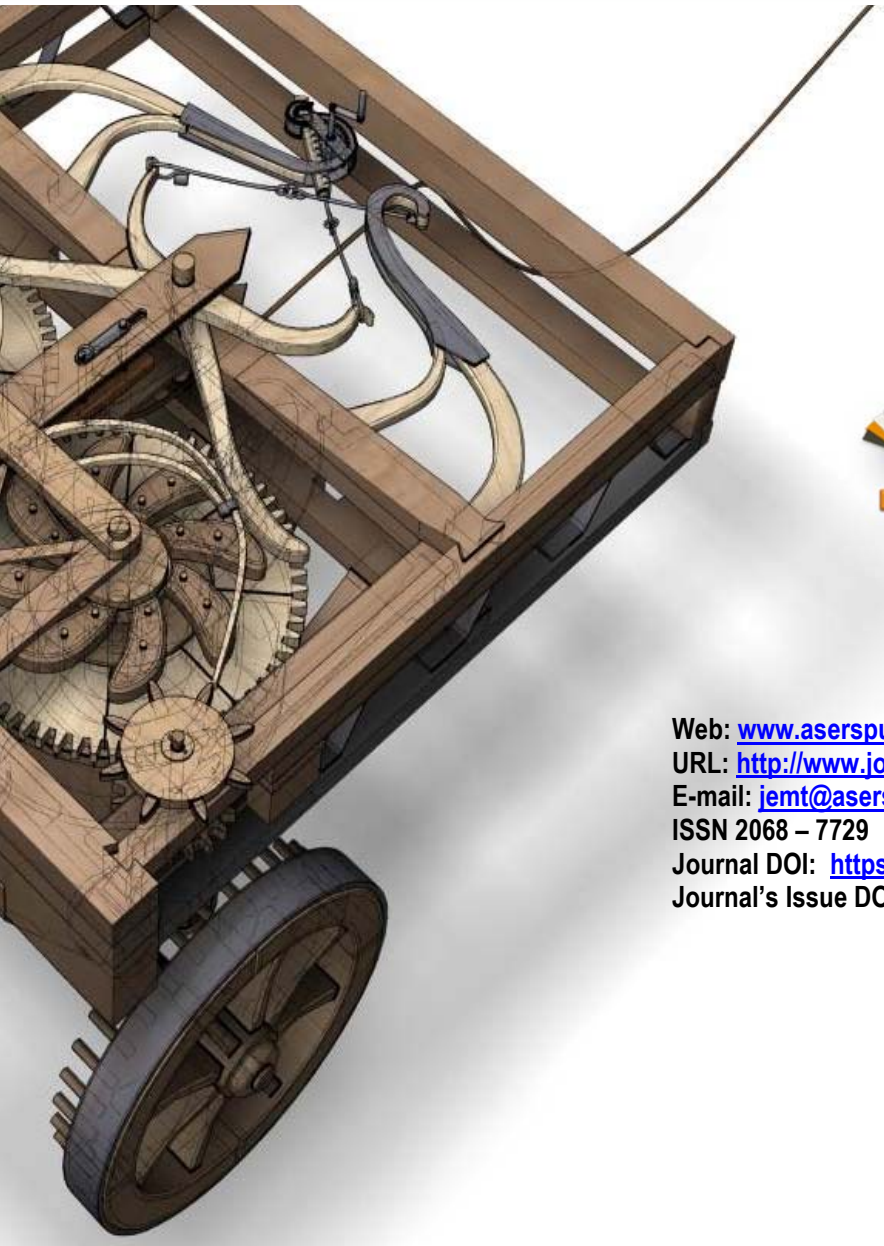

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