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Designing Data-Resolution Dependent Wildlife Corridor Networks for Tigers using a Tensor-Based Computational Model

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Abstract

For many ecological modelling and investigations, data is a key component. As a result, the data resolution employed in the study has a considerable influence on such investigations. The research looks at how data resolution affects the modelling of wildlife corridor networks in a focal landscape. Because wildlife corridors are very species-specific, tigers are the focal species of this study, and the data items used to build tiger corridors are examined in depth.

The current study focuses on applying computational tools to detect and deal with data pieces and data resolution in order to construct wildlife corridor networks. Set theory, membership functions, matrices, and tensor data representation techniques are used in the research. The model presented in this paper shows how data resolution affects our knowledge of tiger mobility in the terrain. The research concluded that the higher is the data resolution, the better will the planning method for wildlife corridor conservation. In addition to GIS and remote sensing, the research supports adequate field studies, which are required for improved modelling. The research will be highly valuable for numerous wildlife stakeholders in terms of strategizing and policy-making in order to protect corridors as part of a bigger objective of species conservation.

Keywords: *Data, Resolution, Set, Tensor, Wildlife Corridor.*

1.0 Introduction

Dispersal of a species from its native area is a crucial life event for all species. These dispersals from the native area to a new range take place along some designated wildlife corridors[20,22]. As a result, wildlife corridors can be defined as landscape components that allow the movement of animals for diverse ecological goals. It becomes particularly species-specific when it comes to the lifecycle of species and the ecological goals that are served. As a result, the corridor can be described as very species-specific[5,11].

Various landscape research and analysis show that protecting and creating adequate wildlife corridors is critical for species conservation[12]. As previously stated, because corridors are species-specific, corridor conservation and design solutions must be species-specific as well. Tigers (Panthera Tigris Tigris) are the species that have been targeted in this work. The goal of this research is to develop a computational model for creating wildlife corridors that takes into account data resolution and its influence on overall tiger corridor network modelling. The depiction of data, which would be highly useful in creating policies for landscape level conservation, is one of the crucial factors before strategizing for conservation[14,17]. The technique presented in this study creates tiger corridor networks using a tensor representation of landscape data.

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It might be claimed that modelling tiger corridors between source and sink habitat areas require computational methodologies. The requirement for such a computational technique is due to the fact that there are several factors that must be deterministically analysed and presented in order to construct tiger corridor networks[13,19]. Such models also highlight the criticals that ecologists must consider while designing corridors. The study discusses a few key computer science foundation aspects that must be applied to such modelling. Initially, the model discusses utilising set theory to remove data duplication, and then it examines the extent to which various characteristics contribute to supporting or hindering tiger movement in the terrain. A matrix representation is used to depict the analysis of these factors. Because the matrix is a mixture of multiple other matrices derived for each parameter, a tensor representation technique has been used[1]. One of the reasons for using the tensor technique is to demonstrate how data, parameters, and the flow of species in the landscape are all affected by data resolution[3].

The article presents an essential research that demonstrates how resolution affects conservation planning tactics in the focus landscape. Three distinct resolution settings are applied to the focus landscape to produce the results. All three resolutions demonstrate how the curvature and geodesic distance of tigers' movement are affected by resolution. As a result, the study concludes that using simply GIS and remote sensing to build wildlife corridors[16,21] is ineffective, and that field investigations are required to develop a better corridor model[10].

The research will help wildlife stakeholders and policymakers, to better understand the important elements of tiger corridor modelling and monitoring for species protection. To demonstrate the model's functionality, a landscape was created using Google Earth.

2.0 Landscape for Study

The terrain used in this piece comes from Rajaji National Park in the Indian state of Uttarakhand. The region that has been investigated for modelling is shown in Figure 1. The forest area is represented by the green region in the landscape, water bodies are represented by light cyan, roads are represented by grey lines, and village regions are represented by polygons bordered by grey lines.

3.0 Methodology

Wildlife corridors, as discussed in the preceding sections, are very species-specific. The landscape characteristics that promote or restrict tiger dispersal are studied for the aim of

Figure 1: Landscape for modelling with Habitat patch 1 as the source habitat patch for tiger dispersal and Habitat Patch 2 as the sink habitat patch

Table 1: Parameters for modelling tiger corridor network

Parameter	Encoding	Remark
Forest	P_0	Supports tiger movement
Water	P_1	Supports tiger movement
Villages	P_2	Inhibits tiger movement
Roadways	P_3	Inhibits tiger movement

modelling tiger corridor networks in the focal landscape[2]. The parameters are represented as *P* set elements. The notion of sets was established to cope with parameter redundancy and eliminate any parameter repetition[6]. This is useful for protecting the model against incorrect predictions.

Only four parameters are examined in this study to keep the model basic and self-contained. Table 1 shows the parameters with encodings and comments for each parameter.

Set *P* of landscape parameters may be represented as:

$$P = \{P_0, P_1, P_2, P_3\} \quad \text{... (i)}$$

Following the construction of *P*, the suggested model's next objective is to determine the grid size by which the landscape is split. The grids presented in this paper are squares of length "*n*" that cover the whole landscape "*A*" with "*m*" grids, as follows:

$$m = \frac{A}{n^2} \quad \text{... (ii)}$$

Landscape grids are analogous to pixels in an image[8]. A tensor 3* resolution of the picture may specify the pixels in a colour image, and similarly, a tensor can represent the grid within a landscape as:

$|P|$* *resolution of data representing the grid* ... (iii)

The cardinality of set is denoted by.

The dispersing tiger in the landscape may be thought to travel across the grids (Yumnam et al., 2014), as the landscape is represented by a collection of "*m*" grids. The movement of the tiger must be supported or inhibited by each grid. To keep the computational framework simple, the researches assumes that the existence of any element of P in the grid determines whether the grid supports or prevents tiger dispersion. The degree of presence indicates how much of the grid is filled by promoting factors and how much is occupied by inhibitory factors (Gulden et al., 2008). As a result, the degree is expressed as a percentage in the landscape.

deg (P_α) = *degree of promoting factor* "a"

$$= \frac{area\ occupied\ by\ a}{total\ area\ of\ grid} * 100 \quad \text{... (iv)}$$

deg (P_b) = *degree of inhibiting factor* "b" = –1*

$$\frac{area\ occupied\ by\ b}{total\ area\ of\ grid} * 100 \quad \text{... (v)}$$

The overall degree of a grid is calculated by adding all of the factors evaluated as:

$$\deg\left(G_{ij}\right) = \sum_{k=0}^{|P|-1} \deg(P_k) \quad \text{... (vi)}$$

According to the above arguments and discussions, each grid would have varying degrees of suitability for allowing tigers to pass across it. The degrees of support provided by a grid for the focal landscape can be expressed as a suitability matrix, using an analogous tensor form as indicated in equation (iii). The suitability matrix is a numerical representation of qualitative aspects of each grid, and each element of the, the suitability matrix may be expressed as:

$$S_{ij} = \deg\ (G_{ij}) \quad \text{... (vii)}$$

The grids that would facilitate the tiger dispersal from a source point are identified using the aforementioned suitability matrix. The whole process presented in this section may be examined, and it can be shown that majority of the work involved in determining the best grids for tiger movement is dependent on data resolution. Data resolution is critical since it affects the degrees of presence of each parameter[15]. The quantitative value of each grid would alter as the degree of presence changes. As a result, the suitability matrix throughout the landscape would shift. The curvature of the tiger corridor is argued to fluctuate with a change in net resolution and the accompanying grid value.

Three possible resolutions on the same landscape are examined with the current technique in the results and discussion section. A comparative analysis of shifting control curvatures is also discovered and reported in addition to the acquired results.

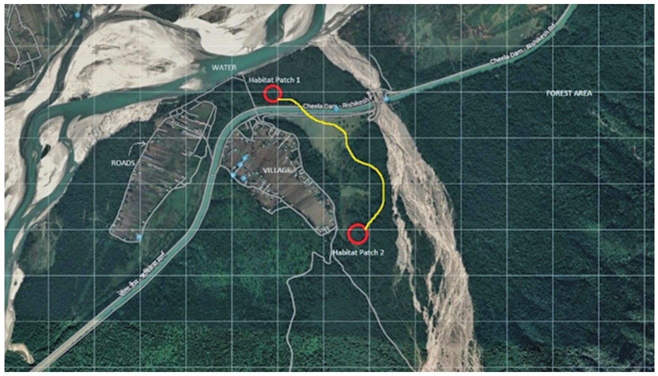

Fig 2. Dispersal corridor for tiger, dispersing from Habitat Patch 1 and reaching Habitat Patch 2 using the model with a resolution of 10*10 sq. units and obtaining the tensor over the landscape.

Fig 3. Dispersal corridor for tiger, dispersing from Habitat Patch 1 and reaching Habitat Patch 2 using the model with a resolution of 5*5 sq. units and obtaining the tensor over the landscape.

Fig.4. Dispersal corridor for tiger, dispersing from Habitat Patch 1 and reaching Habitat Patch 2 using the model with a resolution of 3*3 sq. units and obtaining the tensor over the landscape.

4.0 Result and Discussion

The technique outlined in the preceding section highlights a key feature of wildlife corridor design resolution. The process is applied to the environment under consideration with three distinct resolutions: 10*10, 5*5, and 3*3 square units. The data has been constructed for proposing a computational model in this work and is not satellite generated.

Figures 2, 3, and 4 depict the results of the preceding technique. Figure 2 shows the results of applying the model to a grid of 10*10 square units. Figures 3 and 4 depict the findings for 5*5 square units and 3*3 square units, respectively. It should be emphasised that the findings produced are based on the premise that the dispersing tiger from Habitat Patch 1 must travel the shortest geodesic distance to reach Habitat Patch 2.

The red circles in the collection of images explaining the model findings signify habitat patches, while the yellow arc denotes the obtained tiger corridors.

The foregoing findings reveal a few key facts that must be fully grasped and investigated in order to model tiger corridor networks in a focused landscape. As can be observed from the findings, the overall geodesic distance as well as the curvature of the path reduces as the precision of data resolution increases[23]. As a result, a more realistic model for building tiger corridor networks might be developed with increased resolution. It also suggests that the optimal modelling for wildlife corridor networks might be accomplished by combining field investigations with GIS and remote sensing data.

A crucial finding of the article also suggests that with higher data precision, the perspective of dispersing species might be better examined. The paper introduces a novel feature of encoding data in tensor form, which may aid in decreasing the net time and space complexity related with the computational parts of data analysis to be provided for modelling tiger corridor networks.

5.0 Conclusion

The aforementioned findings were produced utilising extremely basic tiger dispersion logics. It may be argued that the real movement would be far more complex, including the examination of many more criteria[4,9]. The proposed model is unique in that it presents a fundamental computational foundation for modelling tiger corridor networks utilising the tensor approach to data representation. The model may be more promising and produce better results if it was based on actual GIS and remote sensing data.

For modelling wildlife corridor networks, the suggested method emphasises the necessity of data resolution. Wildlife corridor networks are an important part of species protection and should be well researched[18]. The suggested model also implies that while studying wildlife corridor networks, data resolution should be considered. The findings of this study demonstrate how data resolution might alter the curve of tiger's movement. These curvature gradients can be quite helpful in determining how tigers travel over the landscape. The analysis also demonstrates that corridor design should not just rely on GIS and remote sensing data, but should also be backed up by field evidence. As a result, one of the paper's main conclusions is that field research is essential for understanding species migration patterns and analysing the terrain in order to create corridor networks.

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