International Journal of Scientific and Research Publications, Volume 5, Issue 3, March 2015
ISSN 2250-3153

Possibilities of Sharing Multi Species in a Cage Based on Their Food Preference Using Graph Coloring Technique

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Abstract: Clustering has become a special tool in the case of identifying homogeneous groups among large population of dynamic species. Graph coloring technique plays the main role in clustering procedure in many real world problems', since dynamic objects can represent by a graph using a set of vertices, V and a set of edges, E and the graph formed can be clustered in to several number of homogeneous subgraphs according to any considered variable using the graph coloring technique. Basically during this research a vertex coloring algorithm has been used for finding subgraphs (clusters) from the initial graph according to certain order. Our main contribution in this research is investigating the possibilities of multi species sharing the same cage (multi species exhibits) based on their food preference using graph coloring technique at the National Zoological Gardens, Dehiwala, Sri Lanka and proposing an algorithm that can be used to achieve that target for any zoological garden using graph coloring technique for clustering.

I. INTRODUCTION

During the evaluation of zoos, most of zoological gardens were presented a certain collection of species using single species exhibits. As the number of different species getting increased then they have been faced physical problems due to the space limitation when arranging single species exhibits. As a result the idea of mixing different species by considering some factors has become popular increasingly. Presently most of zoos have considerable experience of presenting mixed species exhibits for several fish, reptiles and some for several species of aves class animals. In Sri Lanka also they have considered that option for fish, some aves and some reptiles and presently it has been a successful effort to overcome the space limitation problem up to a certain level. But most of zoos have identified that single species exhibits of mammals were affected for the occurrence of space limitation problem mainly. Then they have focused on mixed species exhibits of two or more mammal species. It is relatively young concept and also it was a new concept to Sri Lanka.

In this case mainly it should be focused on predator - prey relations, feeds, feeding type and the dominant characters. If it is possible to overcome these factors somehow, it can be seen as a special enrichment, which leads a complex, attractive, educable and fantastic experience for visitors. In the case of finding mixed species exhibits of animals can be seen as clustering of dynamic objects in statistically since clustering has become a special tool in the case of identifying homogeneous groups among large population of dynamic species. In many real world problems', graph coloring technique plays the main role of clustering procedure since dynamic objects can represent by a graph using a set of vertices, V and a set of edges, E and graph formed can be clustered in to several number of homogeneous subgraphs according to any considered variable using the graph coloring technique. Basically during this research a vertex coloring algorithm was used for finding subgraphs (clusters) from the initial graph according to a certain order. As a result, it can be obtained mixed exhibits which are homogeneous within exhibits and heterogeneous between exhibits according to the above considered factors. The graph coloring technique can be easily used for clustering for a dynamic population of species as explained above. Similarly during this research the aim was investigating the possibilities of multi species sharing the same cage (multi species exhibits) at the National Zoological Gardens, Dehiwala, Sri Lanka using graph coloring technique and proposing an algorithm that can be used to achieve that target for any zoological garden. The main objectives of this research can be presented as follow.

- The main goal is to educate its visitors about the natural behavior of each animal when different species sharing the same cage.
- Overcome the space limitation problem as much as possible.
- To achieve the second goal it should be determined the minimum number of mixed species exhibits with maximum number of species (using graph coloring technique).
- To present an algorithm which can be determined the cage or cages relevant to a newcomer according to same technique that used before.

II. METHODOLOGY

Graph formed by a set of vertices and edges where each edge having a physical meaning. The set of edges are the connections between vertices. During the clustering of a graph into several subgraphs, the task is grouping a set of heterogeneous vertices into clusters (subgraphs) by consideration of the structure of the edges. In that case there should be many edges within each cluster and relatively few between the clusters. During this research it has been over viewed the definitions and techniques for graph clustering, that is finding highly related vertices using vertex coloring technique. Finally it has been presented a local algorithm for producing clusters for the selected population of vertices of species of the input graph.

Any non-uniform data set can be divided into homogeneous clusters using graph coloring technique. So during this thesis always clustering method has been discussed based on the concept of coloring of a graph. A graph coloring is a process of assigning colors to the vertices of the graph such that. (Witold. 2008)

- No two adjacent vertices (vertices joined by an weighted edge representing the dissimilarity between objects) have the same color, and
- For each color, there exists at least one vertex which is adjacent (has a sufficient dissimilarity degree) to all other colors. This vertex is called a dominating vertex; there can be many within the same class.

Those are the main constraints in coloring of a graph. Even the number of clusters not specified, the coloring based clustering method enables to build a fine partitioning of the data set in to subgraphs (clusters).

A coloring of a graph is an assignment of colors to vertices such that every pair of adjacent vertices receives different colors. The graph coloring problem, whose objective is to minimize the number of colors used. By the way the greedy sequential coloring method is effective in practice when the population of vertices being relatively large. During the sequential coloring method a greedy coloring is applied to again and again over the set of vertices in some order.

Graph coloring and its generalizations are useful tools in modeling a wide variety of scheduling and assignment problems. About a specific application of graph coloring is discussed in this section.

Chemicals store application:

The improper storage or mixing of chemicals can result in serious accidents and even disasters. When keeping several chemicals together at the same place (within same store) it should be consider the incompatibility of Chemicals. Therefore chemicals should be placed by considering the minimum distance among each pair of chemical which is incompatible. Due to the space limitation of the store it is required that placing all the compatible chemicals together (in the same rack). By using the graph coloring technique it can be decide the minimum number of racks that should be used in such cases. Consider the example below. This is only a partial list that includes some of the more common academic laboratory chemicals. Please note that the absence of a chemical from the list does not mean that it is necessarily safe to mix it with any other chemical!

Table 1: List of incompatibility of common chemicals

Chemical	Incompatible with
Ammonia	Mercury(e.g., in manometers), Chlorine, Calcium hypochlorite, Iodine, Bromine, Hydrofluoric acid (anhydrous)
Chlorine	Ammonia, Acetylene, Butadiene, Butane, Methane, Propane (or other petroleum gases), Hydrogen, Sodium carbide, Benzene, Finely divided metals, Turpentine
Iodine	Acetylene, Ammonia (aqueous or anhydrous), Hydrogen
Silver	Acetylene, Oxalic acid, Tartaric acid, Ammonium compounds,
	Fulminic acid
Mercury	Acetylene, Fulminic acid, Ammonia
Fluorine	All other chemicals

It can be obtain the minimum number of rack should be used in the same store for the above chemicals using graph coloring technique as below. (Figure 1) Since fluorine is incompatible with all the other chemicals it has been separated first (red).

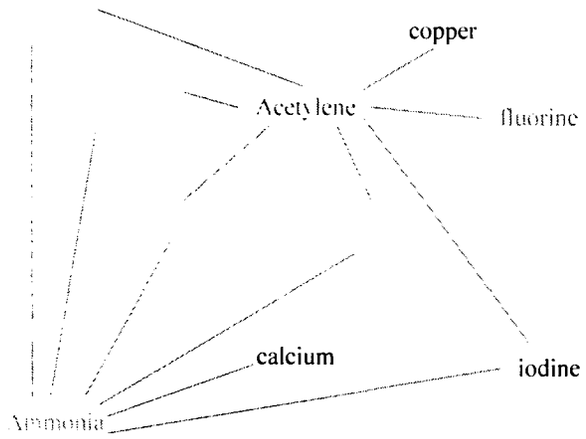

Figure 1: Solution for the incompatibility chemical example with 6 minimum racks.

As discussed above several types of mixed species exhibits were obtained by considering several factors of the species mainly multi species competition for re- sources such as food, space, etc. Although when mixing several species together it should be addressed for disease transmission specially from high risk species. Anyhow if those main effects and factors can be overcome, then the concept of mixed species exhibits provides an interactive and dynamic experience for the animals, visitors and zoo management.

Combining mammals with birds or reptiles within the same exhibit will provide that interactive effect and several benefits for visitors and animals too. But in that case it would be caused to a high risk about the species due the above discussed main effects and factors. Because of that this research was set up to established mixed species exhibits in National Zoological gardens of Sri Lanka by considering concept of mixing species relevant to mammals, aves and reptilia classes separately.

This research was based on some attributes of the animals in the National Zoological Gardens, Dehiwala, Sri Lanka. A complete set of data relevant to the following factors were collected for 220 animals.

- Animal inventory

Class, Order, Common Name & Initial group structure.
Eg. Mammalia, Primates, Toque Monkey, Male-1, Female-2, Unknown-1

- Provided diet list

Common Name, Meal time, Food type & provided amount in g

Eg.

Table 2: Example for the data collected relevant to the animal's diet list

Common Name	Meal time	Food type	Amount in g
Toque Monkey	Morning	Amberalla	7
		Gram	57
		Plantain	121
		Water melon	100
		Apple	11
		Guava/Mango	64

Using the above data a graph was modeled by considering all the animals and all the food types as vertices and edges as the attribute which food type they are consuming. Then the observed clusters can be extracted as a subgraph at each step below by considering the animals as the vertices and considered attribute in the relevant step as the edges using the above modeled graph. A database was created to store the above data and all the partitioning parts were preceded using the graph coloring technique. Since the original graph consists with end vertices of each edge sharing the common attribute, graph coloring was applied for the compliment graph.

The basic steps of the data analysis is given below and the number of exhibits obtained in each step is given within brackets compare to diet and using graph clustering proceed all the steps on whole population of animals.

A). Grouped all the animals in to three classes namely Mammals, Aves and Reptiles. [3 exhibits]

This step has been proceeded to avoid the predator-prey effect to a certain level between each pair of class.

As discussed earlier the whole population of species should be clustered according to the diet combination of each species using graph coloring technique. So the graph coloring technique should be applied for the initially produced graph in the previous section step by step as shown in the above charts. This is known as sequential coloring.

The initial graph was built for the whole population of species and graph coloring was applied to the complement graph for proceed the step 1 to obtain initial three clusters relevant to three classes Mammalia, Aves and Reptilia.

As a result a graph was built by considering each species as vertices and their class (Mammalia, Aves, and Reptilia) as edges.

Example : Let a combination of two mammals (M- Black), two birds (A- Blue) and two reptiles(R- Red). Then there were six vertices and which were connected by edges considering their class. (Figure 2)

Here the identified three clusters (classes) were considered as three separated graphs hereafter.

B). Grouped by carnivore order (Separated those mammals into different exhibits).
[25 exhibits]

This step has been proceeded to avoid the predator-prey effect with a high percentage as discussed in the above step. It can be avoid the predator-prey effect within mammal species by separating carnivore ordered species in to single species exhibits. For that graph coloring technique was applied for the subgraph of Mammalia class species that found above to identify the species of the carnivore order by considering those species as vertices and the order carnivore as edges.

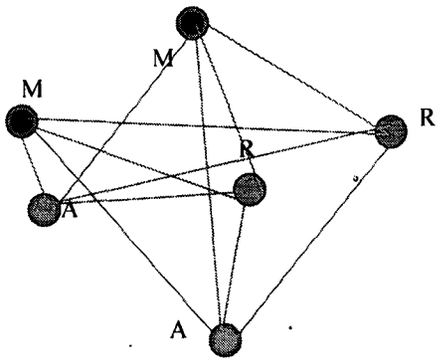

Figure 2: Colored complement graph: Three classes were separated as Mammalia, Aves and Reptilia.

C). The popular feed or feed combination as Papaw, Plantain and Guava/Mango was identified.

Overall 45% of all provided 45 varieties of food types represent from those combinations. It can be justified by considering the percentages of consuming those varieties. Those percentages were as follow.

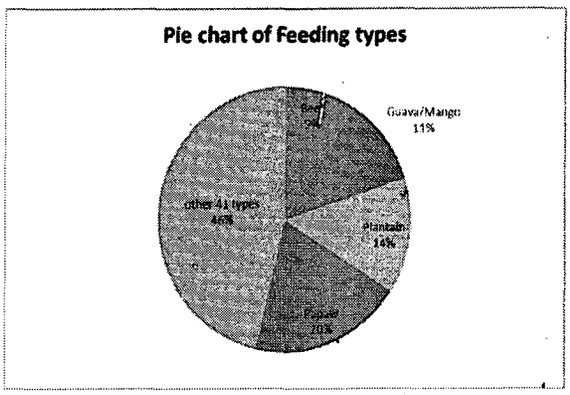

Figure 3: Pie chart of food types

. Papaw 19:5%
. Plantain 14:1%
. Guava/Mango 10:9% and
. Beef - 9% (For carnivore species)

All the remained 46% represents 41 types of remained varieties of food types. So it can be roughly negligible.

The same procedure of graph coloring was followed for the three subgraphs obtained for three classes by considering the species as vertices and the attribute of consuming papaw as edges as discussed in the above step of clustering carnivore animals hereafter. For that it should be considered,

- The subgraph obtained in the initially before step for the relevant class of species
- Rebuild the considered subgraph for the same vertices (species) by considering the attribute of consuming the relevant food type as edges
- Take the complement graph
- Apply the graph coloring technique

The above procedure has been repeated for each subgraph obtained after the each step to get the final result. According to that procedure the following steps of clustering were preceded.

D). Again grouped the each exhibit obtained in first step into two exhibits as having papaw and not having papaw for feeding. [6 exhibits]

E). Again grouped the each exhibit obtained above into two exhibits as having Plantain and not having Plantain for feeding. [12 exhibits]

F). Again grouped the each exhibit obtained above into two exhibits as having Guava or Mango and not having Guava or Mango for feeding. [24 exhibits]

Using a Java programme, the final result was obtained easily according to the above procedure and an interface to display the output was created too.

III. RESULTS OF THE RESEARCH

Finally the fifty number of mixed species exhibits were obtained instead of 220 individual exhibits but one of those exhibits consist the animals.

- Mullary
- Budgerydar

This separation occurred at the first stage of clustering since the class couldn't specify relevant to those animals. So those two animals were considered as outliers during the analysis. All the other 218 animals were involved in the analysis and complete results of all 49 exhibits.
Eg.

1. For class Mammalia and relevant to the feed combination papaw, plantain and not having guava/mango.

Red giant kangaroo, Red necked wallaby, Mouse deer, Squirrel monkey, Long haired spider monkey, White fronted brown lemur, and Slender loris.

2. For class Mammalia and relevant to the feed combination papaw, guava/mango and not having plantain.

Silver pheasant, Malay great argus pheasant, Chinese ringed necked pheasant, Silky bantam, Eurasion collared dove, Diamond dove, victoria crowned pigeon, Green imperial pigeon, Domestics pigeon, and Spotted dove.

IV. CONCLUSSIONS AND RECOMENDATIONS

In this study the method of graph coloring technique was used to a real world problem and it has been successfully completed up to certain level with 49 exhibits of mixed animals instead of 220 individual cages. The final results leads to build a new zoological garden which consists with 49 mixed species exhibits of more space than before since the total number of exhibits has been reduced to 1/4 from the initial number of exhibits approximately. Because of that this method will provides a zoological garden with beautiful surrounding, full of freedom for animals and so calming experience for its visitors. As a result of this study a beautiful opened architectural design can be modeled for each exhibit by considering the real world habitat of each animal. If there is a new comer then the information of it can insert in to the database and by considering the procedure again the exhibit relevant to the new comer could be identified.
This study was set up to support the exchange of expertise in establishing and maintaining mixed species exhibits in zoos of Sri Lanka, as well as to promote the out- standing value of this concept for future animal keeping and exhibition facilities. Mainly this presents mathematical concept behind the clustering of species. Using this concept it can be improved the interface and the grouping procedure based on any other zoological base concept upon several attributes that should be considered during such type of clustering such as size, gestation period, dominant character and feeding method etc. for further studies. Practically it should make high attention 52 for the exhibits which consists with high percentage of all species mainly about the dominant characters on feeding.

ACKNOWLEDGMENT

Foremost, I would like to express my sincere gratitude to my supervisor Dr. G. H. J. Lanel for the continuous support of my M.Sc. study and this research, for his patience, motivation, enthusiasm, and immense knowledge. His guidance helped me throughout research and while writing this thesis. Besides my supervisor, I would like to thank the rest of my thesis committee: Prof. Sunethra Weerakoon and Dr. R. Sanjeewa, for their encouragement, insightful comments, and hard questions. My sincere thanks also go to the Director and the Assistant Director of the National Zoological Gardens, Dehiwala for offering me the opportunity to collect data from the National Zoological Garden and conduct my M.Sc. research upon the data collected from there. Also sincere thanks go to all the other staff members in the National Zoological Garden, Dehiwala who supported me to collect the data that I needed. I wish to thanks specially Mr.Gratien De Almeida for the stimulating discussions and support in making the database, interface and helping to write several programs needed for this study.

Last but not least, I would like to thank my parents and spouse for their immense support during this study.

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