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Study of Safety and Environmental Protection at Sea towards Sustainable Development Using Fuzzy Relational Maps

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Abstract - The concept of sustainable development based on an integrated view of environmental policies and development strategies intends to minimize the risks and hazards to the development. The time has come for efforts to be made on the environmental front towards sustainable development without endangering the ecological assets of the future generations. In this paper we analyze the safety and environmental protection at sea towards cd using Fuzzy Relational maps (FRM). We arrive at the conclusions by this study how sustainable development is being affected by the pollutions.

Key words- Fuzzy Relational Maps (FRM), Environmental Protection, Sustainable development

I. SECTION ONE: FUZZY RELATIONAL MAPS (FRMS)

The new notion called Fuzzy Relational Maps (FRMs) was introduced by Dr. W.B.Vasantha and Yasmin Sultana in the year 2000. In FRMs we divide the very casual associations into two disjoint units, like for example the relation between a teacher and a student or relation; between an employee and an employer or a relation; between the parent and the child in the case of school dropouts and so on. In these situations we see that we can bring out the casual relations existing between an employee and employer or parent and child and so on. Thus for us to define a FRM we need a domain space and a range space which are disjoint in the sense of concepts. We further assume no intermediate relations exist within the domain and the range space. The number of elements in the range space need not in general be equal to the number of elements in the domain space.In our discussion the elements of the domain space are taken from the real vector space of dimension n and that of the range space are real vectors from the vector space of dimension m (m in general need not be equal to n). We denote by R the set of nodes $R_1, \ldots, R_m$ of the range space, where $R_i = \{(x_1, x_2, \ldots, x_m) / x_j = 0 \text{ or } 1\}$ for $i = 1, \ldots, m$. If $x_i = 1$ it means that the node R_i is in the ON state and if $x_i = 0$ it means that the node R_i is in the OFF state. Similarly D denotes the nodes $D_1,\ldots,D_n$ of the domain space where $D_i = \{(x_1,\ldots, x_n) / x_j = 0 \text{ or } 1\}$ for $i = 1, \ldots, n$. If $x_i = 1$, it means that the node D_i is in the on state and if $x_i = 0$ it means that the node D_i is in the off state. A FRM is a directed graph or a map from D to R with concepts like policies or events etc. as nodes and causalities as edges. It represents casual relations between spaces D and R. Let D_i and R_j denote the two nodes of an FRM. The directed edge from D to R denotes the casuality of D on R , called relations. Every edge in the FRM is weighted with a number in the set {0, 1}.

Let e_{ij} be the weight of the edge $D_i R_j$, $e_{ij} \in \{0.1\}$. The weight of the edge D_iR_j is positive if increase in D_i implies increase in R_j or decrease in D_i implies decrease in R_j. i.e. casuality of D_i on R_j is 1. If $e_{ij} = 0$ then D_i does not have any effect on R_j. We do not discuss the cases when increase in D_i implies decrease in R_j or decrease in D_i implies increase in R_j.

When the nodes of the FRM are fuzzy sets, then they are called fuzzy nodes, FRMs with edge weights {0, 1) are called simple FRMs.Let $D_1, \ldots, D_n$ be the nodes of the domain space D of an FRM and $R_1, \ldots, R_m$ be the nodes of the range space R of an FRM.Let the matrix E be defined as $E = (e_{ij})$ where $e_{ij} \in \{0, 1\}$; is the weight of the directed edge D_iR_j (or R_jD_i), E is called the relational matrix of the FRM.It is pertinent to mention here that unlike the FCMs, the FRMs can be a rectangular matrix; with rows corresponding to the domain space and columns corresponding to the range space. This is one of the marked difference between FRMs and FCMs. Let $D_1, \ldots, D_n$ and $R_1,\ldots,R_m$ be the nodes of an FRM. Let D_iR_j (or $R_j D_i$) be the edges of an FRM, $j = 1, \ldots, m$, $i = 1, \ldots, n$. The edges form a directed cycle if it possesses a directed cycle. An FRM is said to be acycle if it does not posses any directed cycle.An FRM with cycles is said to have a feed back when there is a feed back in the FRM, i.e. when the casual relations flow through a cycle in a revolutionary manner the FRM is called a dynamical system.Let D_iR_j (or R_jD_i), $1 \le j \le m$, $1 \le i \le n$. When R_j (or D_i) is switched on and if casuality flows through edges of the cycle and if it again causes $R_i(D_j)$, we say that the dynamical system goes round and round. This is true for any node R_i (or D_j) for $1 \le i \le m$, (or $1 \le j \le n$). The equilibrium state of this dynamical system is called the hidden pattern. If the equilibrium state of the dynamical system is a unique state vector, then it is called a fixed point. Consider an FRM with $R_1, \ldots, R_m$ and $D_1, \ldots, D_n$ as nodes. For example let us start the dynamical system by switching on R_1 or D_1. Let us assume that the FRM settles down with R_1 and R_m (or D_1 and D_n) on i.e. the state vector remains as (10…01) in R [or (10…01) in D], this state vector is called the fixed point.If the FRM settles down with a state vector repeating in the form $A_1 \to A_2 \to \ldots \to A_i \to A_1$ or ($B_1 \to B_2 \to \ldots \to B_i \to B_1$) then this equilibrium is called a limit cycle.

A. Methods of determination of hidden pattern.

Let $R_1, \ldots, R_m$ and $D_1, \ldots, D_n$ be the nodes of a FRM with feed back. Let E be the $n \times m$ relational matrix. Let us find a hidden pattern when D_1 is switched on i.e. when an input is given as vector A_1= (1000...0) in D the data should pass through the

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relational matrix E. This is done by multiplying A_1 with the relational matrix E. Let $A_1E = (r_1, \dots, r_m)$ after thresholding and updating the resultant vector (say B) belongs to R. Now we pass on B into E^T and obtain BE^T. After thresholding and updating BE^T we see the resultant vector say A_2 belongs to D. This procedure is repeated till we get a limit cycle or a fixed point.

II. SECTION TWO: DESCRIPTION OF THE PROBLEM

A. Introduction

Every since man came into existence, he has been trying continually to adopt and adapt his relationship with the changing environment, which consists of not only elements of nature such as air, water and soil but also the social and cultural conditions in which he lives. Over the years this relationship has gone through a metamorphosis and the man, who in the beginning could live in complete harmony with his environment, has shattered its equilibrium irreversibly in the wake of growing population, augmented need of food supply and fast industrial and technological development. It is an undisputable fact that human beings all over the world consuming natural resources are trying to conquer nature instead of preserving and protecting it. In India we did not develop a culture for pollution control. Consequently we have with us today a huge backlog of 57 years of pollution and ecological degradation since independence. The time has come for efforts to be made on environmental front towards sustainable development without endangering the ecological assets of future generation.

Safety and Environmental at SeaSafety of Life at Sea (SOLAS) and protection of Marine Environment is an challenging job for Mariners and Shipping Companies. The IMO (INTERNATIONAL MARITIME ORGANIZATION) had formulated strict rules and regulations which should be complied by all Ships which are engaged in Coastal and International Voyages.The IMO had framed the rules and regulations for discharge of oil which is clearly explained in MARPOL (Marine Pollution). All Ships should comply with these rules at all times during the voyage and at Ports. By following these rules and regulations ships are not allowed to pump out the oil (Heavy Oil, Diesel Oil, Sludge Oil etc) directly to Sea so that Marine Pollution can be avoided. If the oil is directly pumped to the Sea then the Marine life will get affected. There are many marine lives like Fish, Prawns, Tortoise, Crabs, squid etc which will die when the sea water is polluted. Hence IMO had formulated the Discharge criteria in MARPOL Annex I- Regulations for the prevention of pollution by oil. All Ship Master's (Captain's) are advised to follow these regulations strictly to save the Marine life. Failure to comply with these rules the Master will be imprisoned for a minimum period of six months and heavy fine will be imposed to the Master and to that concerned Shipping Company.

III. ENVIRONMENTAL DECLARATION

- The oceans are a vast source of nourishment for mankind and nature which fulfill various needs including food. Pollution is endangering this source. We should make all efforts to remove this threat and help to keep these resources clean and available.
- The protection of the marine environment and the use of ocean resources are co-related. We must exercise care, restrain and understanding while using these resources.
- Maritime transport is an essential part of international commerce.
- Ship generated marine pollution is only a part of the total marine pollution problem and can be eliminated by exercising sufficient care and effort.
- International conventions and national laws for reduction and elimination of ship generated marine pollution cannot be fully affected until every sector of the shipping industry is totally committed to the elimination of marine pollution.
- Such commitment can only be achieved if the regulatory level is complemented by a high level of environmental consciousness in the shipping sector.
- Environmental consciousness can only be achieved through a concentrated effort to educate and inform all sectors of the shipping industry from ship owner to seaman.

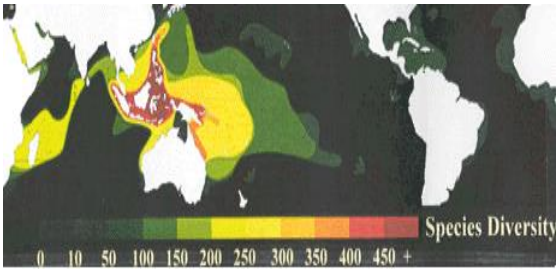

Figure:1Marine biogeography/biodiversity contours

Humans have of course aided this process for as long as they have sailed, mainly by dispersing marine species that have attached to the hulls of vessels. The commencement of the use water as ballast, and the development of larger, faster ships completing their voyages in ever shorter times, combined with rapidly increasing world trade, means that the natural barriers to the dispersal of species across the oceans are being reduced. In particular, ships provide a way for temperate marine species to pierce the tropical zones, and some of the most spectacular introductions have involved northern temperate species invading southern temperate waters, and vice versa.The fine will be imposed according to the nature of violation and depends completely on the extent of pollution occurred at sea. It is estimated that at least 7,000 different species are being carried in ships' ballast tanks around the world. The vast majority of marine species carried in ballast water do not survive the journey, as the ballasting and Deballasting cycle and the environment inside ballast tanks can be quite hostile to organism survival. Even for those that do survive a voyage and are discharged, the chances of surviving in the new environmental conditions, including predation by and/or competition from native species are further reduced. However, when all factors are favourable, an introduced species by survive to establish a reproductive population in the host environment; it may even become invasive, out-competing native species and multiplying into pest proportions.

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As a result, whole ecosystems are being changed. In the USA, the European Zebra Mussel *Dreissena polymorpha* has infested over 40% of internal waterways and may have required between US$750 million and US$1 billion in expenditure on control measures between 1989 and 2000. In southern Australia, the Asian kelp *Undaria pinnatifida* is invading new areas rapidly, displacing the native seabed communities. In the Black Sea, the filter-feeding North American jellyfish *Mnemiopsis leidyi* has on occasion reached densities of 1kg of biomass per m2. It has depleted native plankton stocks to such an extent that it has contributed to the collapse of entire Black Sea commercial fisheries. In several countries, introduced, microscopic, 'red-tide' algae (toxic dinoflagellates) have been absorbed by filter-feeding shellfish, such as oysters. When eaten by humans, these contaminated shellfish can cause paralysis and even death. The list goes on, hundreds of examples of major ecological, economic and human health impacts across the globe. It is even feared that diseases such as cholera might be able to be transported in ballast water. When the on state is taken as node M_2 we see the hidden pattern is the fixed point which is the same binary pair, which makes the nodes M_4 and M_5 to be in the on state in the domain space and makes the nodes Y_1, Y_2 and Y_5 of the range space to be in the on state. Since the working is time consuming, a C program is formulated for finding the hidden pattern.

Type of garbage	Ships outside special areas	Ships within special areas	Offshore platforms (more than 12 nm from land) and all ships within 500 m of such platforms
Food waste comminuted or ground	Discharge permitted ≥3 nm from the nearest land, en route and as far as practicable	Discharge permitted ≥12 nm from the nearest land, en route and as far as practicable	Discharge permitted
Food waste not comminuted or ground	Discharge permitted ≥12 nm from the nearest land, en route and as far as practicable	Discharge prohibited	Discharge prohibited
Cargo residues' not contained in wash water	Discharge permitted ≥12 nm from the nearest land, en route and as far as practicable	Discharge prohibited	Discharge prohibited
Cargo residues' contained in wash water		Discharge permitted ≥12 nm from the nearest land, en route, as far as practicable and subject to two additional conditions*	Discharge prohibited
Cleaning agents and additives' contained in cargo hold wash water	Discharge permitted	Discharge permitted ≥12 nm from the nearest land, en route, as far as practicable and subject to two additional conditions*	Discharge prohibited
Cleaning agents and additives' in deck and external surfaces wash water		Discharge permitted	Discharge prohibited
Carcasses of animals carried on board as cargo and which died during the voyage	Discharge permitted as far from the nearest land as possible and en route	Discharge prohibited	Discharge prohibited
All other garbage including plastics, synthetic ropes, fishing gear, plastic garbage bags, incinerator ashes, clinkers, cooking oil, floating dunnage, lining and packing materials, paper, rags, glass, metal, bottles, crockery and similar refuse	Discharge prohibited	Discharge prohibited	Discharge prohibited
Mixed garbage	When garbage is mixed with or contaminated by other substances prohibited from discharge or having different discharge requirements, the more stringent requirements shall apply		

Figure:2

IV. SECTION THREE: FRM MODEL TO STUDY ABOUT SAFETY AND ENVIRONMENTAL AT SEA

Now using the linguistic questionnaire and the expert's opinion following attributes associated which were the influenced by Responsibility and Authority for controlling environment. Thus the types of Responsibility and Authority are taken as the domain space and the influence of spreading pollution as the range space of the FRM. In choosing the attributes there is no hard and fast rule. It is left to the choice of any researcher to include or exclude any of the attributes.

Attributes Related to the Domain space M given by M = {M_1, …,M_5}

M_1 - Shipboard operations
M_2 - Master Responsibility and Authority
M_3 - Non-Conformities and Reportings
M_4 - Maintenance of the Ship and Equipment
M_5 - Resource and Personnel

Attributes Related to the Range space Y given by Y = {Y_1, …,Y_7}

Y_1 -Oil.
Y_2 -Noxious liquid substances in bulk.
Y_3 -Harmful substances in packaged forms.
Y_4 -Sewage from ship.
Y_5 -Garbage.
Y_6 -Ship air
Y_7 -Vessel getting collided.

Now using the expert's opinion who is a media person we have the following relation matrix. We have M_1.M_2, M_3,M_4,M_5 as the rows and $Y_1$2,Y_2,Y_3,Y_4,Y_5,Y_6,Y_7 are the columns.

$$A_1 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 1 & 0 & 0 \end{bmatrix}.$$

The hidden pattern of the state vector X = (0 1 0 0 0) is obtained by the following method:

XA_1 ↪(0 1 0 0 0 0 0) = Y
YA_1^T ↪(0 1 0 1 0) = X_1
X_1A_1 ↪(0 1 0 0 1 0 0) = Y_1
$Y_1A_1^T$ ↪(0 1 0 1 1) = X_2
X_2A_1 ↪(1 1 0 0 1 0 0) = Y_2
$Y_2A_1^T$ ↪(0 1 0 1 1) = X_3 (say)
X_3A_1 ↪(1 1 0 0 1 0 0) = Y_3 (say)

(Where ↪ denotes the resultant vector after thresholding and updating)

When we take M_2 in the ON state (i.e. films /movies) and all other attributes to be in the off state.We see the effect of X on the

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dynamical system A_1 is a fixed point given by the binary pair {(0 1 0 1 1), (1 1 0 0 1 0 0)}. When we take flims/movies node alone in the on state we get say X = (0 1 0 0 0) The resultant to be the fixed point given by the binary pair {(0 1 0 1 1), (1 1 0 0 1 0 0)}. When the on state is taken as node M_2 we see the hidden pattern is the fixed point which is the same binary pair, which makes the nodes M_4 and M_5 to be in the on state in the domain space and makes the nodes Y_1, Y_2 and Y_5 of the range space to be in the on state. Since the working is time consuming, a C program is formulated for finding the hidden pattern. The casual connection matrix A_2 is given by the second expert who is a doctor.

Let $M_1.M_2$, M_3,M_4,M_5 taken along the rows and $Y_1,Y_2,Y_3,Y_4,Y_5,Y_6,Y_7$ along the columns.

$$A_2 = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 & 1 & 0 & 0 \end{bmatrix}$$

Suppose the state vector X = (0 0 0 1 0) ie., the node internet is in the on state condition and all other nodes are in the off state. We see the resultant binary pair using the C - program is given by {(1 0 0 1 0), (0 1 0 0 0 1 0)} which is the fixed point. When we take the state vector X_1 = (0 0 0 1 0) ie., the node internet i.e., M_4 in the on state and all other attributes be in the off state we see the effect of X_1 on the dynamical system A_2 is a fixed point given by the binary pair {(1 0 0 1 0), (0 1 0 0 0 1 0)} The interpretation of the hidden pattern of several state vectors using several experts is used in this paper to arrive at the conclusion. To show the mode of working we have just given two experts opinion.

V. CONCLUSIONS AND SUGGESTIONS

The concept of 'Development without destruction' and 'Environment planning for sustainable Development' are given top priority in all our self-destruction.Government and company should take more concrete efforts to promote safety objectives methods such as:Safe and efficient transportation of bulk cargo mainly coal.Ensure the safety and well being of all personnel engaged in the business through Establishing safeguards against all identified risks connected with ship's operations and safe working environmentEnsure the protection of the sea and the environment. Continuous improvement inworking practices and safety management skills of personnel ashore and aboard ships.Adopt implementation of all mandatory rules/ regulations.Maintenance of the ships equipment in between surveys.Therefore our environment has a limit to bear the onslaught of its exploitation is to be unmistakably understood. Nevertheless the fact that environmental resources are not limitless is always to be kept in mind during all development programme and planning processes.

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