The Study of Hazards of Plastic Pollution Using Induced Fuzzy Cognitive Maps (IFCMS)

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Abstract - Plastic is one of the chemical materials which poses Environmental problem. Plastic is made up of various chemical elements. Therefore, it is regarded as a highly contagious material that does not easily degrade in the natural environment after its usage or utility period. Plastic causes serious damage to the environment during its production and disposal process. Polyethylene, polyvinyl chloride, polystyrene are largely used in the manufacture of Plastics. Hence, this paper analyzes the hazards of Plastic pollution using Induced Fuzzy Cognitive Maps (IFCMS). IFCMs area fuzzy-graph modeling approach based on expert’s opinion.

Keywords - Induced fuzzy Cognitive Maps (IFCMS), Plastic Pollution, Health Hazards.

I. INTRODUCTION

Plastic in the Environment is regarded to be more an aesthetic nuisance than a hazard, since the material is biologically quite inert. Plastics are used because they are easy and cheap to make and they can last for a long time. Unfortunately these same useful qualities can make Plastic a huge pollution problem. Because the Plastic is cheap it gets discarded easily. But its persistence in the environment can do a great harm. The United Nations Environmental Programme (UNEP) 2011 yearbook considers Plastic pollution in the ocean to be one of the three greatest emerging environmental problems in the world [1].

When exposed to natural elements, Plastic breaks down into tiny molecules but never fully biodegrades. Plastic is a commodity that is consumed on a large-scale all around the world. The production as well as disposal of Plastic, pose a great threat to all the life forms on earth. This material takes years to decompose, which is one of the factors that kill many animals in water as well as on land. During the manufacture of Plastic, many hazardous chemicals are emitted which has resulted into dreadful disorders and diseases in humans [2]. Ethylene oxide, xylene and benzene are some of the chemical toxins present in Plastic that has miserably effects on the environment.

Any form of Plastic disposal too, causes harm to the environment in which we dwell. Burning the Plastic causes contamination of atmosphere due to the release of poisonous chemicals [3]. Disposing Plastic into water or land causes contamination and even increases the mortality rate of animals. The rural areas are more prone to any kind of pollution due to poor disposable systems. The people from rural areas often use Plastic bags and bottles on a large-scale. Unaware of the harm caused due to Plastic, rural people are a contributing factor to pollution. Also wind carry and deposit the Plastic from one place to other, littering the land. It also gets stuck on fences, trees and water bodies. Any animal that comes in the vicinity of plastic, might even get tangled and suffocate to death. The maximum damage is done by Plastic carry bags [4]. Shops delivering goods in Plastic bags and the people who insist on having Plastic carry bags when they buy goods are responsible for Plastic pollution. Therefore Plastic management or Plastic waste management [5] involves the techniques to be used to manage the Plastic waste in an environment friendly way and helping in the proper utilization of Plastic material. This paper deals with the environmental hazards and some remedial measures for Plastic pollution using Induced Fuzzy Cognitive Maps (IFCMS) based on gathered information. Section two presents the basic definitions and section three presents the analysis using the IFCM model. In fourth section we draw the conclusions from our analysis and proposed remedial measures.

II. BASIC NOTION AND DEFINITIONS

We proceed to state the definitions of IFCM model.

A. Definition

Fuzzy Cognitive Maps (FCMs) are digraphs that capture the cause/effect relationship in a system. Nodoset, the graph stands for the concepts representing the key factors and attributes of the modeling system, such as inputs, variables, states, components factors, events, actions of any system. Signed weighted arcs describe the casual relationships, which exist among concepts and interconnect them, with an edge of causality. The constructed graph clearly shows how concepts influence each other and how much the degree of influence. Cognitive Maps (CMs) were proposed for decision making by Axelrod [6][7] for the first time. Using two basic types of elements: concepts and casual relationship, the cognitive map can be viewed as simplified mathematical models of belief system. FCMs were proposed with the extension of the fuzzyfied casual relationships. Kosko [7][8], introduced FCMs as fuzzy graph structures representing casual reasoning. When the nodes of the FCM are fuzzy sets, then they are called fuzzy nodes. FCMs with wedge weights or causalities from these set {−1, 0, 1} are called simple FCMs. Consider the nodes/concepts $P_1, P_2, P_3, \ldots, P_n$, of the FCM. Suppose the directed graph is drawn with wedge weights $w_{ij}$ from $-1, 0, 1$.

B. Definition

The matrix M is defined by $M = (e_{ij})$ where $e_{ij}$ is the weight of the directed edge $P_i \rightarrow P_j$ in the adjacency matrix of the FCM, also known as connection matrix. The directed edge $e_{ij}$ from the casual concept $P_i$ to concept $P_j$ measures how much $P_i$ causes $P_j$. The edge $e_{ij}$ takes values in the interval $[-1, 0, 1]$. $e_{ij} = 0$ indicates no causality.
e_{ij} \geq 0 \text{ indicates casual increase/positive causality.}

e_{ij} \leq 0 \text{ indicates casual decrease/negative causality.}

Simple FCMs provide quick first-hand information to an expert’s stated causal knowledge. Let $P_1, P_2, \ldots, P_n$ be the nodes of FCM. Let $A = (a_1, a_2, \ldots, a_n)$ is called the state vector where $a_i = 0$ or 1. If $a_i = 0$, then the behavior in the OFF state and $a_i = 1$, then the behavior in the ON state. For $i = 1, 2, \ldots, n$. Let $P_i \neq P_j, P_2 P_3, \ldots, P_n$, the state of the FCM $(i \neq j)$. Then the edges form a directed cycle.

C. Definition
An FCM possesses a directed cycle. An FCM with cyclicity said to have a feedback, either is a feedback in FCM, i.e., when the causal relations flow through acyclic are evolutionary way, the FCM is called a dynamical system. The equilibrium state for the dynamical system is called the hidden pattern. If the equilibrium state of a dynamical state is a unique state vector, it is called a fixed point or limit cycle. Information from the hidden pattern summarizes the joint effect of all interacting fuzzy knowledge.

D. Algorithmic approach to FCM
Even though FCM is a sophisticated of FCM, it has a slight modification only in Algorithmic approaches [9][10][11]. To derive an optimistic solution to the problem with unsupervised data, the following steps to be followed:

Step 1: For the given model (problem), collect the unsupervised data that is in determinant Factors called nodes.

Step 2: According to the expert opinion, draw the directed graph.

Step 3: Obtain the connection matrix, $M$, from the directed graph (FCM). Here the number of rows is the given number of nodes.

Step 4: Consider the state vector $S(X)$. By setting $c_i$ in ON position that is assigning the first component of the vector $M$ and the rest of the components as 0. Find $S(X) \times M$. The state vector is updated and threshold is each stage.

Step 5: Threshold value is calculated by assigning 1 for the values $>0$ and 0 for the value $<1$. The symbol $\Rightarrow$ represents the threshold value for the product of the result.

Step 6: Now each component in the $C_i$ vector is taken separately and the product of the given matrix is calculated. The vector which has maximum number of one’s is found.

The vector with maximum number of one’s which occurs first is considered $C_1$.

Step 7: When the same threshold value occurs twice, the value is considered as the fixed point. The iteration gets terminated.

Step 8: Consider the state vector $C_1$ by setting $C_2$ in ON state that is assigning the second component of the vector $C_1$ and the rest of the components as 0. Precede the calculations discussed in Steps 4 to 6.

Step 9: Continue Step 9 for all the state vectors and find hidden patterns.

III. ANALYSIS USING IF CM MODEL

We take the following attributes in the case of Environmental Hazards:

- $C_1$: Plastics blocks the open sewage system and results in stagnation of sewage water, becomes breeding place for mosquitoes which leads to the spread of water and air borne diseases.
- $C_2$: Plastics dumped on the soil prevents water percolation into the ground, reduces ground water level and also the poison in the waste. Plastics mix with rain water, seep through the ground and drain into nearby streams and lakes.
- $C_3$: Burning of Plastics results in releasing of toxins in the atmosphere which causes cancerous diseases like cancer and associated with skin, respiratory problems by exposure and inhalation of toxic fumes.
- $C_4$: Due to improper disposal systems, many cattle’s and other animals consuming Plastics results in ending of their life. Birds are also affected by eating Plastics.
- $C_5$: Plastic waste dumped into rivers, find its way to ocean and seas affects the marine life. Marine creatures such as dolphins, turtles, whales, penguins are killed every year by these Plastics.
- $C_6$: Many animals mistaking them as food and the ingested Plastics remain after death and decomposition of the animals.
- $C_7$: The Manufactures of Plastics dispose the Plastic waste and chemicals used in the process of manufacturing Plastic material into water channels causing health hazards to living organisms in and around it.
- $C_8$: Plastics which affect the marine life in turn pose a direct threat to human beings who consume fish that have taken Plastics.
- $C_9$: In Plastic manufacturing, it releases chemicals such as Biphenyl, Styrene Trimer and Styrene Monomer, which alters the reproductive systems of human beings.

According to Ecologist opinion, the same set of 8 attributes has been converted into a connection matrix $M$.

\[
M = \begin{bmatrix}
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1
\end{bmatrix}
\]

Analysis using IF CMs:

Step 1: Let $C_1 = (1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0)$

\[C_1 = M \times C_1 = \begin{bmatrix}
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1
\end{bmatrix} \times \begin{bmatrix}
1 \\
0 \\
0 \\
0 \\
0 \\
0 \\
0 \\
0
\end{bmatrix} = \begin{bmatrix}
0 \\
0 \\
0 \\
0 \\
0 \\
0 \\
0 \\
0
\end{bmatrix}
\]

Step 2: When the same threshold value occurs twice, the value is considered as the fixed point. The iteration gets terminated.

$C_2' = M \times C_2 = \begin{bmatrix}
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1
\end{bmatrix} \times \begin{bmatrix}
1 \\
0 \\
0 \\
0 \\
0 \\
0 \\
0 \\
0
\end{bmatrix} = \begin{bmatrix}
0 \\
0 \\
0 \\
0 \\
0 \\
0 \\
0 \\
0
\end{bmatrix}
\]

Step 3: When the same threshold value occurs twice, the value is considered as the fixed point. The iteration gets terminated.
The use of plastic is a part of human activity. Plastics dumped on the soil prevents water percolation into the ground, reduces ground water level and also the poison in the waste. Plastics mix with rain water, seep through the ground and drain into nearby streams and lakes. C4 [Due to improper disposal systems, many cattle’s and other animals consuming Plastics results in ending of their life. Birds are also affected by eating Plastics] and C5 [In Plastic manufacturing, it releases chemicals such as Biphenyl, styrene Trimer and styrene Monomer, which alters the reproductive systems of human beings|plays the important role in this study. The limit points corresponding to C5(10011010), C6(11001110) and C7(00110100) highlights almost all the attributes which seems to be major causes of Plastic pollution.

IV. Conclusion

It requires self-discipline to solve this Plastic pollution caused by using Plastic things in our day today life. Our Dependence on the private organization and government will not solve these problems. The use of Plastic is a part of human need. Therefore, we have to follow some simple ways to solve this existing problem. So, we suggest the following remedial measures. Limited usage of Plastic carry bags will help the environment free from pollution. Using glass bottles, cloth and paper bags which are biodegradable and recyclable will reduce Plastic pollution. Using Plastic carry bags again and again for our daily shopping, instead of throwing them out in the first use itself will reduce the manufacture of Plastic carry bags. Collect all waste Plastics in our home and donate it to the recycling centers, will help road constructions, save cattle’s life and also prevents other pollutions. Avoid burning the things made up of Plastics which will help us to control the air pollution and also by doing so our respiratory disease gets reduced.

REFERENCES