

REVIEW OF LITERATURE

Fuzzy logic is a system for representing uncertainty, or possibility. The formal extension of the original possibility theory created in the 1920s by Lukasiewicz was developed by Zadeh. A generalization of traditional, bivalent, Aristotelian logic, fuzzy logic creates a system for mathematically representing systems with natural linguistic variables e.g., tall, little .

Fuzzy models are mathematical tools introduced by Zadeh (1965). Later Politician scientist Axelord (1976) used this fuzzy model Cognitive Map (CM) to study decision making in social and political systems. CM is signed digraph design to represent causal assertion and belief system of a person (or group experts) with respect to a specific domain, and use that statement in order to analyze the effect of a certain choice on a particular objective. The credit **for** the creation of cognitive Maps is quite rightly awarded to Edward Tolman (1948).

Using the concepts of neural networks and fuzzy logical approach Bart Kosko (1986) proposed some models which extend the idea of Cognitive Map by allowing the concept to be represented linguistically with an associated fuzzy set. This model are well suited to get a clear representation of the knowledge to support **the** decision making process and assist in the area of computational intelligence, which involves the application of soft computing methodologies even though the given inputs are vague, uncertain and even contradictory in nature.

From an artificial intelligence point of view, FCMs are supervised learning fuzzy-neural systems, where as increasingly, data are available to model the problem, and the system becomes better at adapting itself and reaching a solution. FCMs are a fuzzy graph modelling approach based on **the** expert's opinion. This is a non - statistical approach to study the problems with imprecise information. In a graphical form, the FCMs are typically signed fuzzy weighted digraphs, usually involving feedbacks, consisting of nodes and directed edges between them. According to Codara (1998), FCMs can be used for

several purposes, including four functions. 1) *Explanatory*: It is focused on reconstructing the premises behind the behavior of **giving** agents, understanding the reasons for their decisions and for the actions they take and highlighting any distortions and limits in their representation of the situation. 2) *Prediction*: This function is based on predicting the future decisions and actions, or the reasons that a given agent will use to justify any new occurrences. 3) *Reflective*: This function helps decision makers to ponder over their representation of a given situation in order to ascertain its adequacy and possibly prompt the introduction of any necessary changes. 4) *Strategic*: The last function is based on generating a more accurate description of a complex situation. In general terms, an FCM is built by mixing the current experience and knowledge regarding a system. This can be achieved by using a human experts' team to describe the system's structure and behaviour in different conditions. FCM is a straightforward way to find which factor should be modified and how. In this sense, an FCM is a dynamic modeling technique in which the resolution of the system representation can be increased by applying further mapping (Y.Miao, Z.Q Liu, C.K.Siew and C.Y.Miao (2001) G. Glykas (2010). During the three decades, FCMs played a vital role in the applications of diverse scientific areas, such as social and political sciences, engineering, information technology, robotics, expert systems, medicine, education, **production**, environment, and so on. Aguilar (2005) was the first who tried to gather the FCM applications in different scientific domains. After 2004, a large number of research studies related to methodologies to construct or enhance FCMs, as well as innovative applications of FCMs, emerged. A collection of papers with applications in various disciplines is presented in the book "*Fuzzy and Tools*" edited by Glykas and prefaced by Kosko (Glykas (2010)

Areas of Applications

Fuzzy Cognitive Maps have been utilized in numerous research and industrial areas. They can be roughly divided into applications in medicine, earth and environmental sciences, engineering, and economics, business and management.

It is worth mentioning here, the book entitled 'FCMs and Neutrosophic Cognitive Maps' by Vasantha and Smarandache2003 (2003). This book infers that FCMs strongly resemble neural networks and powerful for reaching consequences as a mathematical tool for modeling complex systems.

Implications for interdisciplinary Reading: National Implication by Calais (2008), FCM based tool for prediction of infectious diseases by Elpiniki et al. (2009), Benefits of literacy in Bhutan by Devadoss et al. (2007), Problem faced by **bonding** laborers near Kodaikanal forests discussed and **solutions** given by Vasantha (2008) **is** notable studies in this area of research. In all the above studies, the various real life problems with imprecise information taken and the precise solutions given by FCM and its advanced studies.

The breadth and number of applications provide motivation for the proposed research and thus a brief summary of selected applications, which are organized in chronological order for each application domain **are** presented in the next few subsections.

Medicine

Georgopoulos et al. (Georgopoulos et al., 2001; Georgopoulos et al., 2003; Georgopoulos et al., 2005; Georgopoulos and Stylios, 2008; Stylios et al., 2001) applied FCMs to help with the diagnosis of Specific Language Impairment (SLI) and to support the speech therapist in the diagnosis process. Stylios et al. (2001) proposed a model based on FCMs that utilized the evaluation of cardiocographic signals with other physiological data to create an advanced decision-making support system. Papageorgiou et al. (2002) used FCMs in radiotherapy treatment planning to estimate the radiation dose.

Earth and Environmental Sciences

Banini and Bearman (Banini and Bearman, 1998) presented an FCM approach to study the interaction between various factors that affect slurry rheology. Satur and Liu (Satur and Liu, 1999a; Satur and Liu, 1999b; Liu and Satur, 1999) used FCMs to develop a supportive tool to analyze data from the Geographic Information System (GIS). Hobbs et al. (Hobbs et al., 2002) applied the FCM as a method to study the objectives of ecological **rehabilitation**, focusing on the analysis of responses from the ecosystem to management. Fons et al. (Fons et al., 2003; Fons et al., 2004) performed an FCM-based analysis of the impact of establishing an eco-industrial park. Ozesmi and Ozesmi (Ozesmi and Ozesmi, 2003) used FCMs to support the management plan for establishing a lake.

Engineering

In one of the first applications of FCMs in engineering, Styblinski and Meyer (Styblinski and Meyer, 1988) explored their usefulness to the qualitative electrical circuit analysis. Pelaez and Bowles (Pelaez and Bowles, 1995; Pelaez and Bowles, 1996) applied FCMs to describe the failure modes of a system. Lee et al. (Lee et al., 1996) proposed a system that performed on-line fault diagnoses with the use of FCMs. Another example using FCM technique, fault management and diagnosis, was authored by Ndousse and Okuda (Ndousse and Okuda, 1996). Subsequent applications are related to the robotics field. Hashimoto and Yamaguchi, followed by Ando et al. (Hashimoto and Yamaguchi, 1997; Hashimoto, 2000; Ando et al., 2001), proposed an application of FCMs to describe a system with an agent. An analysis of electronic **circuit** troubleshooting using FCMs was presented by Perusich (Perusich, 2007; Perusich, 2008) whereas mobile robot troubleshooting was discussed by Yeap et al. (Yeap et al., 2008). Risk management in a distributed system using an example of distributed databases was modeled and analysed by **the** De Korvin et al. (De Korvin et al., 2007). Distributed wireless peer to peer networks were modeled with an FCM by Li et al. (Li et al., 2009) to help develop a novel peer selection scheme.

Economics, Business and Management

Kardaras and Karakostas (Kardaras and Karakostas, 1999) studied the application of **FCMs, as** an alternative method to existing Strategic Planning of Information Systems. Koulouriotis et al. (Koulouriotis et al., 2001a) performed a stock market analysis and prediction with the use of FCMs, which were used to construct a stock market model. Jetter (Jetter, 2003) applied FCMs to model the early phases of a new product development, which was used to support decision making. Borrie and Ozveren (Borrie and Ozveren, 2004) utilized FCMs to describe a dynamic market environment using an example of the electricity market in the United Kingdom. Another illustration of using **the** FCM-based methodology in economics was presented by Carvalho and Tome (Carvalho and Tome, 2004) who developed a model of tax rate evolution in Europe. FCMs were also utilized to model and forecast stock markets by Froelich and Wakulicz-Deja (Froelich and Wakulicz-Deja, 2008). Schlager and Pernul (Schlager and Pernul, 2008) studied trust and its role in e-commerce by developing and analysis of a corresponding FCM model. In 2009, an

application of FCMs to credit risk evaluation was proposed by Buyukozkan and Vardaloglu (Buyukozkan and Vardaloglu, 2009), whereas Noori et al. (Noori et al., 2009) applied FCMs as a tool for modeling factors related to organizational conflict management.

Other Application Areas

Perusich (Perusich, 1996; Perusich and McNeese, 2005) investigated the application of FCMs, as an intelligent analyst in case of a terrorist attack. FCMs were also applied in political sciences (Tsadiras et al., 2001; Andreou et al., 2005), pattern recognition (Hu et al., 2004; Pajares and De la Cruz, 2006; Papakostas et al., 2008), document classification (Peng et al., 2008; Zhou and Zhang, 2008), protein structure prediction (Kurgan et al., 2007; Nguyen et al., 2008). Most recent applications include modeling of agro-ecosystems (Rajaram and Das, 2010), cryovolcanic activity on Titan (Furfaro et al., 2010), and defense planning in combating terrorism Akgun et al., 2010.

Vasantha Kandaswamy and Yasmin Sultana (2000) introduced the Fuzzy Relational Maps (FRM) and Linked Fuzzy Relational Maps (LFRM) and analysed the Employee and Employer Relationship. Vasantha(2004) studied the HIV/AIDS affected Migrant Labourers and their Socio economic conditions. Vasantha Kandaswamy and Victor Devadass (2004) have introduced the fuzzy models are Combined Disjoint Block FRM (CDBFRM). Combined overlap block FRM (COBFRM) .Pathinathan et.al. (2005) have introduced a New model called Induced Model. This model gives proper representation to the unsupervised data and studied about Tensions and Causes for school dropouts. This Induced model generates the following models. ie, , Induced Combined Fuzzy Cognitive Maps(ICFCM), Induced Combined Disjoint Block Fuzzy Cognitive Maps (ICDBFCM), Induced Combined Overlap Block FCM(ICOBFCM), Induced Fuzzy Relational Maps(IFRM), Induced Linked Fuzzy Relational Maps (ILFRM), Induced Combined Disjoint Block Fuzzy Relational Maps(ICDBFRM), Induced Combined Overlap Block Fuzzy Relational Maps (ICOBFRM), Induced Fuzzy Associative Memories (IFAM), Induced Bi-directional Associative Memories (IBAM).

Integrating the Fuzzy Models of FCM and FRM, a new model called FCRM bimodel is constructed. Its examined, how effectively this FCRM could be used to analyse a social problem. It proved that the new model could also best be employed in the study of

problems in Science and Technology .This bimodal to capture the suffering, feelings or emotional trauma faced by the rural persons with disability (PWD) and the caretakers. Combining and simultaneously working of the two fuzzy model Fuzzy Cognitive Maps and Bi- directional Associative Fuzzy Cognitive Dynamical System (BAFCM) is introduced by Thirusangu et. al., (2012) and analysed the problem on the health hazards of rag pickers.

As there are many models present in the literature, we have chosen CETD matrix, FCM, CFCM, IFCM models to analyse the problems of Endosulfan victims and designed a new model MFCM (Maximum Fuzzy Cognitive Maps) in this work.

Many articles we have reviewed in the following topics CETD, FCM, CFCM AND IFCM are presented here.

- A. Victor Devadoss, A.Felix, Immaculate Anbarasi, (2013) *Women Teachers Affected By Stress in Chennai Schools Using CETD Matrix* Indo-Bhutan International Conference on Gross National Happiness

Stress is experienced by all in their everyday lives, in a wide variety of situations and settings. It is a natural and unavoidable feature of life experienced at one time or another by the vast majority of those engaged in professional work. The objective of this paper is to find out the peak age of women teachers gets stressed in Chennai Schools. For that the job stress among women workers was studied.It has been classified into six symptoms as Increased Blood Pressure, Cholesterol, Stomach acids, Production of blood sugar for energy, Headache, Heavy work. For the first time in the year 1998 matrix theory was developed by W.B.Vasantha and V. Indira to study the passenger transportation problem. To study this problem, they divided and defined four types of matrices are called Initial Raw Data Matrix, Average Time Dependent Data matrix (ATD Matrix), Refined Time Dependent Data matrix (RTD Matrix) and Combined Effects Time Dependent Data Matrix (CETD Matrix). In the year 2003 the same technique was used by W.B. Vasantha to study the migrant laborers who were affected by HIV/AIDS. In 2004 W.B. Vasantha and A. Victor Devadoss used to study the agriculture laborers. In 2012, A. Victor Devadoss and M. Clement Joe Anand used it to study the dimensions of personality of women in Chennai.

Now this model to study of women teachers affected by stress in Chennai Schools was used.

- G. Kuppaswami, R. Sujatha and W. B. Vasantha Kandasamy (2015) *Study of Traffic flow using CETD Matrix*, Indian Journal of Science and Technology

This paper presents a method to analyze the traffic flow pattern in Velachery Vijaya Nagar Signal, Chennai. Study of traffic congestion is significant these days so that traffic regulation can be made accordingly to avoid congestion and waiting time. The peak time and non-peak time are identified using the row sum of the Combined Effective Time Dependent Data (CETD) matrix in this duration.

- W.B. Vasantha Kandasamy, Elumalai, Victor Devadoss and Mary John. (2005). *Application of CETD Matrix Techniques to Study the Social and Psychological Problems Faced by Rag Pickers*, Vikram Mathematical Journal

In this paper it is studied that the problems faced by the social and psychological problems faced by the rag pickers using CETD matrix. Majority of rag pickers interviewed were children below the age of 15. Most of them were runaways from home, school dropouts or orphans. The information were collected from 200 rag pickers in Chennai and have studied the problem using CETD matrix. This is the first time we are using an algebraic approach to study the problem faced by rag pickers using matrices. The solution is got as a column matrix which gives the associated numbers which is transformed into graph which will depict the highest age group in which they take up the profession of rag picking. A complete grading of age group is given by this method. From the CETD matrix analysis we see that in the age group 16-20 are the most hypersensitive so they land up in streets even for small problems and become rag pickers. The next age group is from 10-15 with row sum adding up to 23 following a single digit positive sum 9 in the age group 21-25 and it is more an impossibility for one to start his carrier as a rag picker when he is in the age group of 26-30 or 31-40 or that is after 25 year of proper life a person may not become a rag picker at 25. In the age group 5-9 they never become rag pickers.

- Kosko, Bart (1985) *Fuzzy Cognitive Maps*, International Journals of Man –Machine Studies

Fuzzy Cognitive maps (FCMs) are fuzzy graph structures for representing casual reasoning. Their fuzziness allows hazy degrees of casuality between hazy casual objects (concepts). Their graph structures allow systematic casual propagation, in particular forward and backward chaining, and it follows knowledge bases to be grown by connecting different FCMs. FCMs are especially applicable to soft knowledge domains and several example FCMs are given. Casuality is representing as a fuzzy relation on casual concepts. A fuzzy casual algebra for governing casual propagation on FCM is developed.

- Julie A, Dickerson and Bart Kosko (1994) *Virtual World as Fuzzy Cognitive Maps* Department of Electrical Engineering –System Signal and Image Processing Institute University Of Southern California .Los Angeles.California .

Fuzzy Cognitive Maps (FCM) can structure virtual world that change with time. An FCM links causal events, actors , values , goals and trends in a fuzzy feedback dynamical system. An FCM lists the fuzzy rules or casual flow paths that relate events. It can guide actors in a virtual world as the actors move through a web of cause and effect and react to events and to other actors .Experts draw FCM casual picuters of the world. They do not write down differential equations to change the virtual world .Complex FCM can give virtual with new or chaotic equilibrium behavior .Simple FCMs give virtual worlds with periodic behavior. They map input states to limit cycle equillibria. An FCM limit cycle repeats a sequence of events or a chain of action and responses. Limit cycles can control the steady state rythms and patterns in a virtual world. In nested FCMs each casual concept can control its own FCM or fuzzy function approximator. This gives levels of fuzzy system that can choose goals and casual webs as well as move objects and guide actors in the webs. FCM matrices sum to give a combined FCMvirtual world for any number of knowledge sources . Adaptive FCMs change their fuzzy casual web as casual pattern change and actors act and experts state their casual knowledge. Neural learning laws change the casual rules and the limit cycles. Actors learn new patterns and reinforce old ones. In complex FCMs the user can choose the dynamical structure of the virtual world from a spectrum that ranges from midly to wildly non linear .We use a simple but adaptive model an undersea virtual world of dolphin, fish, and sharks.

- M. Glykas, (2010) ***Fuzzy Cognitive Maps: Theory, Methodologies, Tools and Applications***, Springer Verlag

The challenging problem of modeling and controlling complex systems is investigated using Fuzzy Cognitive Maps (FCMs). A mathematical description of FCM models is presented, new construction methods and an algorithm are developed and extensively examined. The issue of modeling the supervisor of large complex systems is addressed and is modeled using a FCM. A manufacturing example is used to prove the usefulness of the proposed method. The problem of Decision Making process in Decision Analysis is considered and analyzed using FCM models. A successful application of FCM theory in a health problem is provided.

- Uygur Özsesmi (2006). ***Fuzzy Cognitive Maps Of Local People Impacted By Dam Construction: Their Demands Regarding Resettlement*** Department of Environmental Engineering, Erciyes University, Kayseri, Turkey,

Fuzzy cognitive mapping was used to understand the wants and desires of local people before resettlement. Variables that the affected people think will increase their welfare during and after dam construction were determined. Simulations were done with their cumulative social cognitive map to determine which policy options would most increase their welfare. The construction of roads, job opportunities, advance payment of condemnation value, and schools are central variables that had the most effect on increasing people's income and welfare. The synergistic effects variables demonstrated that the implementation of different policies not only add cumulatively to the people's welfare but also have an increased effect.

- W. Ritha, M. Mary Mejrullo Merlin (2012) ***Are Creative Teachers Blissful or Stressful?" - An Empirical Study using Fuzzy Cognitive Map Constructor*** Journal of Computing Technologies

Infusing creativity elements on the curriculum frameworks becomes an international trend and need in the present educational era. So, teachers and administrators today are under tremendous pressure to recognize and value the creativity and inculcate it in every child. But focusing intimately on creative teachers (or) teachers teaching creativity, are they

delightful (or) stressful? This present research study aims to scrutinize all the relevant factors faced by creativity teachers and to prioritize the factors which draw the solution for the above query. Fuzzy Cognitive Maps are widely accepted as tools for factor evaluation and prioritization. It is the most adapted tool for any social/physical problem with unsupervised data. Undoubtedly, this work assist the educationists and creative professionals the psychosomatic impact of various creativity activities on creative teachers. Infusing creativity elements on the curriculum frameworks becomes an international trend and need in the present educational era. So, teachers and administrators today are under tremendous pressure to recognize and value the creativity and inculcate it in every child. But focusing intimately on creative teachers (or) teachers teaching creativity, are they delightful (or) stressful? This present research study aims to scrutinize all the relevant factors faced by creativity teachers and to prioritize the factors which draw the solution for the above query. Fuzzy Cognitive Maps are widely accepted as tools for factor evaluation and prioritization. It is the most adapted tool for any social/physical problem with unsupervised data. Undoubtedly, this work assist the educationists and creative professionals the psychosomatic impact of various creativity activities on creative teachers.

- A.Praveen Prakash , A.Saraswathi and A.Rajkumar (2013) *A Study on problems of Trans-genders in India using Fuzzy Cognitive Maps (FCMs)*. International Journal of Emerging Trends in Engineering and Development

Ever since the United Nations has passed the Universal Declaration of Human Rights in 1948, the Rights of the marginalized sections of society have been in focus among the human right activists. The Rights of the minorities such as the religious minorities, linguistic minorities, gender minorities (Transgenders) etc form important part. Only when the UN insisted that all nations who are signatories to the above declaration should take steps to ensure the adherence of the declarations.UN has declared 1994-2004 as decade of human rights. In the year 1993 India has formed National and State Commissions for Human Rights. From then on India has taken measures to ensure human rights of the minorities in general and and that of the gender minorities viz, the trasgenders in particular. But the level of awareness on the rights of transgenders among themselves as well as among the masses is very low. This marginalized section of people live in a very deprived and exploitative status with low self- esteem. This paper analyses the various problems of

the transgenders as expressed by the leaders of the transgenders and the NGO leaders who have been working for their up-liftment using Fuzzy Cognitive Map (FCM) model.

- Elpiniki Papageorgiou, Chrysostomos Stylios, Member, and Peter Groumpos (2006.) *A Combined Fuzzy Cognitive Map and Decision Trees Model for Medical Decision Making*. Annual International Conference of the IEEE Engineering in Medicine and Biology Society

Fuzzy Cognitive Maps (FCMs) are an efficient modeling method providing flexibility on the simulated system's design. They consist of nodes-concepts and weighted edges that connect the nodes and represent the cause and effect relationships among them. The performance of FCMs is dependent on the initial weight setting and architecture. This shortcoming can be alleviated and the FCM model can be enhanced if a fuzzy rule base (IF-THEN rules) is available. This research proposes a successful attempt to combine fuzzy cognitive maps with decision tree generators. A combined Decision Tree-Fuzzy Cognitive Map (DT-FCM) model is proposed when different types of input data are available and the behavior of this model is studied. In this research work, we introduce a new hybrid modeling methodology for decision making tasks and we implement the proposed methodology at a medical problem.

- A.Victor Devadoss, S.M.A. Shahul Hameed (2012) *A Study of the Attitudes of Road User using Combined Fuzzy Cognitive Maps (CFCMs)* International Journal of Computer Applications

Today's world is a fast moving world. As consequence it meets with more road accidents. The growing number of vehicles, population and indiscipline attitude of road users are some of the concerns for the road accidents and road congestion. In recent years the number of road accidents growing rapidly. In particular, the victims are the youth of every country. This is our main concern for taking this study. In this paper we use Combined Fuzzy Cognitive Maps (CFCMs) to study the attitudes of road users. This paper has four sections. In section one gives the Basic notation and definition. Section two describes the hidden pattern of CFCMs. Section three deals with the Description of the problem and analysis using Combined Fuzzy Cognitive Maps. In final section gives the conclusion and suggestion based on our study.

- Praveen Prakash, N. Lakshmi pathy, J. Esther Jerlin (2014) ***Problems of Housemaids in Chennai City: A Study Using Combined Fuzzy Cognitive Maps (CFCMs)*** Proceedings of the World Congress on Engineering

A domestic worker is a person who works within the employer's household. Domestic workers perform a variety of household services for an individual or a family, from providing care for children and elderly dependents to cleaning and household maintenance, known as housekeeping. Responsibilities may also include cooking, doing laundry and ironing, food shopping and other household errands. Some domestic workers live within the household where they work. This paper analyses the problems of housemaids in Chennai city using Combined Fuzzy Cognitive Mapping (CFCM) Model. This gives the result in an effective way by combining the opinion of two or more experts. This paper consists of four sections. Section one deals with the causes for the problems, which is introductory in nature. Section two gives the description of Combined Fuzzy Cognitive Map model. Section three deals with the attributes involved that states the causes for such a problem and uses CFCM to analyze the problem. Section four gives the conclusion and suggestions based on the study.

- W. Ritha, M.Mary Mejrullo Merlin (2011) ***Predictors of interest in cosmetic surgery-An analysis using induced fuzzy cognitive maps (IFCMs)***, Annals of Fuzzy Mathematics and Informatics

Cosmetic surgery has been a growing fascination for many people over the last couple of decades. There are number of qualitative factors predicts interest towards cosmetic surgery. This study analyses the possible factors such as interpersonal, social and intrapersonal factors and empirical factors like Appearance based rejection sensitivity, Personal re-jection sensitivity etc. Hence, this research investigates the most predictin/ impactful factor of predicting interest in cosmetic surgery using Induced Fuzzy Cognitive Maps (IFCMs). IFCMs are a fuzzy-graph modeling ap-proach based on expert's opinion. This is the non-statistical approach to study the problems with imprecise information

- Dhruvajyoti Ghosh and Anita Pal (2015), ***Using Fuzzy Cognitive Map and Induced Fuzzy Cognitive Map to Analyze Real World Problems.*** Annals of Pure and Applied Mathematics

In last few years Private Organization or Information Technology (IT) organization are known as hot sector for investment. Employees' performance plays a vital or critical role towards the growth of any private or IT organization. Employees play a good role to produce and increasing Indian software or any other services in terms of both profit and global developments of customers in the global platform. But to reach the goal, they are insensitive to their social and personal life. Private employees those who work in various sector mainly IT field are facing mental stress, staying away from families, divorce, visions problem, affected by various addictions. We have analyzed the problem of their daily life with the help of Fuzzy Cognitive Maps (FCM) and Induced. Fuzzy Cognitive Map (IFCM). FCMs and IFCMs are fuzzy-graph modelling approaches based on expert's opinion. This is the non-statistical approach to study the problem with imprecise information. FCM and IFCM is the best suited tool when the data is an unsupervised one.

- S. Narayanamoorthy and S.Kalaiselvan. I.J. (2012), *Adaptation of induced fuzzy cognitive maps to the problem faced by the power loom workers*, Intelligent Systems and Applications,

The Indian textile industry has a significant presence in the economy as well as in the international textile economy. In this research Paper we study the socio economic problems faced by power loom workers in Avinashi in Tamilnadu, India, using Induced Fuzzy Cognitive Maps (IFCMs). We have interviewed 50 households in the study area using a linguistic questionnaire. As the problems faced by them at large, involved so much of feelings and uncertainties. We felt it to fit to use fuzzy theory in general and induced fuzzy cognitive maps in particular. For IFCMs is the best suited tool when the data is an unsupervised one.

ENDOSULFAN

Endosulfan is used primarily on food crops like tea, fruits , and vegetables on grains.Commercial names for the product include Thiodan , Endocide, Beosit, Cyclodan,Malix, Thimul and Thifor. Endosulfan is a highly toxic chemical, poisonous to most living organisms. The United States Environmental Protection Agency classifies it as 'highly hazardous'. Endosulfan is readily absorbed by humans via the stomach, lungs and

through the skin. Endosulfan is one of the world's most dangerous chemical pesticides, causing immediate and severe health impacts. It is listed by the World Health Organisation (WHO) as Class II- *moderately hazardous* but other authorities believe this underestimates its hazardous potential. It is very toxic to humans when inhaled or ingested, and harmful when it comes into contact with skin. A 2007 United States Environmental Protection Agency (USEPA) assessment concluded that it cannot be used safely in the majority of scenarios for which it is currently approved, and classifies Endosulfan as Category 1b - *highly hazardous*. Meanwhile, the Intergovernmental Forum on Chemical Safety (IFCS) reported that it poses significant health problems for developing countries and economies in transition.

Furthermore, Endosulfan belongs to a group of chemicals termed 'persistent organic pollutants' (POPs), which are characterised by their high toxicity, long range transportation and persistence in the environment for long periods. POP chemicals also bioaccumulate; they store easily within fatty tissues and biomagnify by building up in food chains. The chemical has been found in remote regions including the Arctic, Antarctic, Alps and Himalayas and traces have been detected in the tissues of animals worldwide, including polar bears, antelope, crocodiles, Minke whales and African vultures. It is also a widespread contaminant of human breast milk.. These critical aspects of long-term environmental pollution, together with health concerns, have led to Endosulfan being banned from use in 62 countries from the EU to Saudi Arabia and Mali to Cambodia. The European Union has proposed a global ban, currently under consideration, under the Stockholm Convention on POPs.

If such a listing occurs, it will, in effect, lead to a global ban on Endosulfan's production and use. Currently, the Indian Government, itself a major producer of Endosulfan, vigorously opposes any international ban, stymieing efforts by other nations to safeguard human health and environmental protection. Here are just 10 reasons for which Endosulfan should be banned.

- ❖ **High acute toxicity**
- ❖ **Permanent neurological impairment**

- ❖ **Endocrine disruption**
- ❖ **Male reproductive disorders**
- ❖ **Birth defects**
- ❖ **Liver and kidney damage**
- ❖ **Genotoxicity in human cells**
- ❖ **Persistent global navigation**
- ❖ **Bioaccumulation in food web**
- ❖ **Air and water contamination**

The plight of people in Kerala State, India, is a particularly dramatic example of how Endosulfan use can devastate human health. A combination of 20 years of aerial spraying on cashew plantations and mango trees unique circumstances mean that residents were excessively and repeatedly exposed to the chemical. In the initial years of spraying, few residents had ever seen a helicopter or plane and would come out of their homes to watch, getting showered with the chemical where they stood. Workers in the plantations were also directly exposed to Endosulfan as they stood on the edges of the fields during spraying, marking the boundaries of the spray zone. Aerial spraying of the pesticide over the cashew plantations technically should have taken place no more than 3m from the canopy level but, because of power lines above the fields spraying was conducted at a higher height enabling the pesticide to be spread further. Workers and locals were then re-exposed indirectly to the chemical during their daily tasks such as washing in contaminated water and burning contaminated wood during cooking. The state ban is a success for Kerala, but the suffering in this unique case does highlight the need for global elimination. Unfortunately, the Government of India is heavily invested in the continued use of Endosulfan, as it owns one of the largest global manufacturers, Hindustan Insecticides Ltd.

A detailed report on the harmful effect faced by people with the usage of pesticides in India, was telecasted in “SATYAMEVA JAYATHE”(2012) (<http://youtu.be/o9uForVzTOA>) Many articles on Endosulfan are published in newspapers like The Hindu,

Times of India , Malyala Manorama and Mathrubhumi. These raised deep concern and motivated to select the problem of Endosulfan victims for the present research work

There are seven Buds schools formed in Kasargod for the study of Endosulfan affected children. Teams of dedicated teachers are transforming the lives of the “Endosulfan children”. From helpless and often cranky children, they are developed into brilliant students who excel in academics and other activities. The walls of the Buds schools are full of achievements. The paintings by the children and the certificates they earned cover these walls as the symbols of their survival.

Nandana is a victim of the Endosulfan tragedy in Kasaragod. She was suffering from a mental condition that made her violent. A very different Nandana in the Buds school at Periya is found. Now 15 year old, she is all smiles while she plays among other children. She does not get aggressive at all. The teachers had also pacified a big girl who used to tear off her clothes and defecated when and where she wanted. Teachers started training her by taking her to the washroom every half an hour .At 20 years of age, she finally learned to handle herself. Buds schools could also start medical examinations to ensure care for these affected children. Padmaraj, who overcame his Endosulfan-caused handicaps to top the tenth-standard equivalency test in the whole of Enmakaje panchayat, will soon have his little dream fulfilled. A collective of photographers in Kottayam has decided to gift him a computer. Padmanabha Mesthiri has been carrying his 21-year-old son for two decades. The persistence pays off. Padmaraj wants to be a teacher or a singer, or maybe both. He had expressed his wish to learn about computers. The Masters Camera Club read about the boy’s wish on Manorama and offered to help him. Kasaragod comes to the news columns often as the starting point of a state wide rally organised by one of the political parties. There are, however, many individuals and associations who have offered a helping hand to the victims of Endosulfan, from Leelakumari Amma of Periya who brought the tragedy to the world’s notice to activists of the younger generation. An umbrella organisation working against the application of Endosulfan has benefited the victims. The state government was prompted to announce a pension scheme for the victims and concepts such as the Buds schools after their intervention. The government’s efforts also paid off with the forming of a cell to address the miseries of Endosulfan. The government had

appointed a special nodal officer for the cell. Relief and rehabilitation measures meant for the victims are carried out through different departments of the Government.

1. Health Department – Identification and categorization of the victims, free treatment Home based, Palliative Care, Physiotherapy Unit, Mobile Medical Units
2. Civil Supplies Department: Free ration being provided to all Endosulfan affected families
3. LSGD/ Education Department: Buds School facility is being provided Mentally Retarded Children . Six buds schools are functioning in Endosulfan Panchayat
4. Revenue Department: The Government have ordered payment of Rs.5.Lakhs each to the completely bedridden, Mentally retarded Patients, to the next kin of those who died. A payment of Rs.3.lakhs to be given to the Physically Disabled Patients
5. NABARD –RIDF Package: Special package for Endosulfan affected area which includes water supplies schemes, construction of Bud’s schools, Anganwadi Centres, Health Centre with the total estimation of 200 Crores.

Social activist M.A. Rahman sarterd the Endosulfan Victims’ Support Aid Group (Envisage) with M.T. Vasudevan Nair and the late U.R. Ananthamurthy as patrons. The group is still providing support to the victims’ families. Associations such as DYFI and Solidarity had also worked among the victims. DYFI had built houses for them. M.A. Rahman and Ambikasuthan Mangad highlighted the issues through their documentaries. Manorama (2015).

As the Endosulfan victims are not given the benefits announced by the government, a strike from January 26, 2016 at secretariat in Kerala is conducted by Endosulfan victims and have been called off after the government agreed to most of their demands. Chief Minister Oommen Chandy announced that 610 more people will be included in the Endosulfan affected list. The Chief Minister made the announcement after holding talks with Endosulfan victims who have been conducting an indefinite strike. The decision to waive the debt of Endosulfan victims was taken earlier. The procedure to provide money for this purpose will be over by February 8. The Endosulfan victims will be

categorized into three different sections. A three member committee has been appointed for this purpose. The Government has decided to increase the compensation amount recommended by National Human Rights Commission in 2010 to Endosulfan victims. A compensation amount up to Rs 3 lakh will be given from now on to the victims. The Government will also hold five medical camps this month at the affected areas. Talking into consideration the shortage of doctors in Endosulfan affected regions; the Chief Minister said that Rs 20,000 will be given as extra money to the doctors who come for duty in Endosulfan affected region. (<http://english.mathrubhumi.com/news/kerala/Endosulfan-victims-strike-ends-govt-agrees-to-demands-english-news-1.840980>)

India has agreed to phase out use of Endosulfan by 2017 and all existing stock of the pesticide in the country that is past its expiry date. Minister of State for Agriculture Sanjeev Kumar Balyan, while speaking on a Private Member's Bill said even now the use of the pesticide had been banned after the Supreme Court passed an interim order. He was speaking after members had expressed their views on a Bill introduced by P Rajeev (Communist Party of India(Marxist)) which sought ban on the use and sale of the pesticide Endosulfan which was harmful for human beings. Mr Balyan said his ministry had introduced a Pesticides Management Bill in Rajya Sabha and the matter is also sub-judice so a separate legislation to ban a single pesticide is not desirable. He said that at the Stockholm Convention, India had agreed to phase out the use of Endosulfan by 2017. Mr Rajeev initially said he did not find the minister's reply satisfactory, but withdrew the Bill after the minister said that his suggestions about talking to Health ministry for establishing a hospital in Kerala and on issuing notification to ban Endosulfan would be considered. (<http://www.ndtv.com/indianews/indiatophaseoutuseofEndosulfanby2017government647081>)

Endosulfan is not the only viable option for protecting crops, and promoting sustainable, economically and technically viable alternatives to Endosulfan will help secure public and environmental health. Alternatives do not have to reduce crop yields either; sixty-two countries have banned the use of Endosulfan and are introducing alternatives that can maintain yields. Furthermore, alternatives may have to be used as pests continue to become resistant to the chemical; at present, resistance has developed in at least 28 species affecting at least 22 crops. There are less toxic chemical alternatives, and Integrated Pest

Management (IPM) is a method of reducing or avoiding some of the worst aspects of chemical pesticide use. A 2008 PAN Germany report noted that Endosulfan, which lost its national registration approval in 1991, has been successfully replaced with other methods, including non-chemical pest control methods in an IPM system⁹⁶. However, IPM does not eradicate the use of pesticides, and many farmers around the globe are therefore taking the opportunity to convert their production to organic methods, thereby eliminating the risks posed by chemical pesticides (as well as fungicides and herbicides). This development can be welcomed for its positive role in protecting human health and the natural environment, without compromising the livelihood needs of farmers. Organic farming is better for the environment, safer for workers and could increase profit margins for farmers. There are numerous botanical pesticides that can be grown and mixed by farmers with comparably no risk to health. These include larvaticides formulated using aloe extract; repellents using plants like lemongrass or coriander, or cow urine or buttermilk solutions; and insecticides using ginger and chilli. Farmers can even formulate botanical rodenticides using *Gliricidia* or the leaves and unripe fruit of papaya plants. Many of the plants used in these formulations have multiple benefits for crop growing. Neem, for example, is a repellent, insecticide, antibacterial agent, anti-fungal agent, antifeedant, a growth inhibitor, and crop and grain protectant. Organic farmers in India have shown that organic practices can be far more profitable than conventional methods, with revenues from organic sales approximately 30% higher than from conventional sales. Alternatives to Endosulfan use have proven to be environmentally sustainable and socially and economically viable. Increasing numbers of farmers are turning to organic production methods that utilise a variety of means to control pests naturally, and without resorting to chemical pesticides.

1.1 Endosulfan

Kerala, the southern state of India in the west coast is known as the “God's Own Country” and Kasargod, the northern district of this state has a village called 'Swarga' which literally means paradise. Around 1963-64, the Kerala Government brought cashew plantation to Kasargod district covering around 4600 hectares. In 1978, the Plantation Corporation of Kerala (PCK) took over the control of these cashew plantations. To prevent the pests, which affect trees during flushing, flowering and fruit set, PCK started aerially spraying Endosulfan thrice a year for almost two decades. Palakkad is another district in Kerala, where 300 land holders own big plantations of mango trees and use Endosulfan extremely during flowering season to kill pests, leaf miners and leaf hoppers. Endosulfan was introduced at a time when environmental awareness and knowledge about the toxicology of such chemicals were low and not mandatory as per national laws. Then slowly farmers started using Endosulfan to control the pests in vegetables, fruits, and paddy, cotton, tea, coffee, tobacco and timber crops.

1.1.1: Endosulfan

Endosulfan is an organo chlorine insecticide. Its chemical formula is $C_9H_6Cl_6O_3S$. Endosulfan exists as colourless crystals. Technically Endosulfan is a mixture of two isomers- α - Endosulfan and β – Endosulfan in the ratio 7:3. The industrial Toxicological Research centre (ITRC) in India which is the nodal centre for the Regional Based Assessment of Persistent Toxic Substances (PTS) for the Indian Ocean region by the United Nations Environment Programme. Global Environment Facility (UNEP-GEF) classifies Endosulfan as extremely hazardous (Anon 1989). Endosulfan is listed as a Persistent Organic Pollutant (POP) in the Convention on Long-range Transboundary Air Pollution (LRTAP). The worldwide production of Endosulfan was 10,000 MT in 1984 (Anon 2003). Many countries that produced Endosulfan in the 1970s and 80s do not produce it any more. For instance Endosulfan has not been produced in the United States since 1982. In European Union, Germany is the only producer of Endosulfan and it is

manufactured at a single site. In EU, the 90% of the whole Endosulfan in 1999 were used in Mediterranean area. Spain, Italy, Greece and France are the major consumers. Endosulfan is produced mainly in Israel, India, China and South Korea. India is one of the major producers of Endosulfan.

1.1.2: Effects of Endosulfan

A person is exposed to Endosulfan by

- Breathing air near where it has been sprayed.
- Drinking water contaminated directly or through run-offs.
- Being in contact with contaminated soil.
- Eating contaminated food.
- Smoking cigarettes made from Endosulfan contaminated tobacco.
- Working at Endosulfan production centres.
- Direct ingestion

Endosulfan is acutely toxic and has been implicated in many cases of poisoning and fatalities. It has been identified with a range of chronic effects, including cancers and impacts on hormonal systems, exhibiting similarities with its predecessor in the organochlorine class.

(a) Acute effects

A number of acute poisoning cases have been reported. Ingestion or breathing high levels of Endosulfan may lead to convulsion and death. Endosulfan directly affects the central nervous system (Anon 1996,2001) and recurrent epileptic seizures are also reported (Migiloranze K.S 2004) Symptoms of poisoning by Endosulfan include hyper activity, dyspnea (breathing difficulty), apnea (stoppage of breathing), salivation, loss of consciousness, diarrhea, anemia, nausea, insomnia, blurred vision, cyanosis (bluish discoloration of skin due to want of oxygen), foaming at the mouth, tremor, dry mouth, irritability, head ache, haematuria, albuminuria, imbalance and lack of coordination. (Anon 1989, 1984, 2000), Susan Sang and Sania Petrovic (1999). Symptoms of poisoning include death, irritation of stomach and small intestine, congestion of kidneys, lungs and adrenals, neurotoxicity, erythema, atonia, desquamation, hemorrhagic lung, granular livers (Karatas et al. 2006; Sliva, 2007).

(b) Chronic effects

The chronic toxicity studies of Endosulfan in animals and human suggest that the kidneys, liver, immune system, and testes are the main target organs. Long term exposure is linked to immunosuppressant, neurological disorders, congenital birth defects, chromosomal abnormalities, mental retardation, impaired learning and memory loss (Sliva 2007). Endosulfan may also be a part of the cause for the disease in the quality of semen, an increase in testicular and prostate cancer, an increase in defects in male sex organs, and increases incidence of breast cancer which has been observed in the last fifty years (Saiyed et al., 2003; Chitra etl al., 2001; Singh and Pandey, 1990; Sinha et al., 1995; Soto et al., 2008). The National Institute of Occupational Health (India) have linked the higher prevalence of neurobehavioral disorders, congenital malformations in female children and abnormalities related to male reproductive systems to the continuous exposure to Endosulfan spray by the study conducted among children in one of the villages in Kasargod district in the South Indian State of Kerala where Endosulfan was aerielly sprayed.

1.1.3. Effects of Endosulfan to the Environment, Wildlife and Domestic Animals.



Environmental Justice Foundation (2009) End of the Road for Endosulfan

Endosulfan sulphate will be present in the environment as a result of the use of Endosulfan as an insecticide. If Endosulfan sulphate is released to water, it is expected to absorb to the sediment and may bio concentrate in aquatic organisms. Endosulfan is persistent in the environment. Endosulfan degrades relatively quickly in water but persists longer in soil. It is highly worrying that a report by the International Programme on Chemical Safety stated that Endosulfan has been shown to persist on the hands of pest control operators for up to 31 days after exposure (International Programme on Chemical Safety 1984). Endosulfan is a persistent chemical that has been demonstrated to bioaccumulate in exposed organisms. The effects of Endosulfan on non-target species can be swift and devastating. Farmers in Benin have observed birds and frogs dying following consumption of insects sprayed with Endosulfan. Endosulfan is also extremely toxic to aquatic life. Endosulfan runoff from cotton fields killed over 240,000 fish in Alabama (USA). Frog and toads hatched from eggs exposed to low Endosulfan concentration exhibit a depressed “avoidance behaviour”, increasing their likelihood of predation (Raloff, 1998). Endosulfan was found toxic to earthworms, causing a significant reduction in the growth rate and total protein content. Reversible blindness and lack of muscle coordination has been reported in sheep and cattle grazing on Endosulfan contaminated grass. (Anon 1996). Cows and chicken were observed to die of mysterious causes. People were also complaining that their domestic animals had suffered miscarriages, bleeding, infertility, stunting of growth and deformities. The reason for the above happenings is due to Endosulfan. Residues of Endosulfan have been found in indoor air, in all kind of water resources and in sediment, soil, tree bark, aquatic plants, fish, crocodile eggs and other living things. Residue have also been found in food around the world, in dairy foods, meat, chicken, vegetable oil, peanuts, seeds, fruit, honey, rice and many different vegetables. A detailed report on the harmful effect faced by the people with the usage of pesticide in India was telecasted in Star Vijay T.V. dated June 24, 2012 “SATYAMEVA JAYATHE” <http://youtu.be/o9uForVzTOA>, episode 8 anchored by film star Aamir Khan. Many articles including Shaji, K. A (2010, 2014) and Malayala Manorama (2015) on Endosulfan are published in newspapers.

1.1.4. Endosulfan Poisoning in Kasargod, Kerala.

The Endosulfan tragedy in Kasargod district of Kerala in India is now well known. It is considered by many experts in the field of pesticide toxicity as one of the worst pesticide disasters to happen to a region and its people. The tragedy occurred for various reasons, starting with the recommendation to use such a chemical in a populated, water body rich area like Kasargod. The aerial spraying of Endosulfan over the cashew plantations in Kasargod district in Kerala was started in 1978. This was done 3 times a year over an area covering 15 gramma panchayath in Kasargod. There were many warning signals about its impact from the beginning, including the mass deaths of bees, fishes, frogs, birds, foxes and also congenital deformities in domestic animals like cows. It was then continually aerielly sprayed by the plantation corporation of Kerala(PCK) on its Cashew plantations for 20 years, without even once looking into its impacts. In 1994, independent health observations by a local doctor, Dr. Mohankumar revealed that there was a rising incidence of cases of mental illness and congenital anomalies in Kasargod. He initially considered the possibility of heavy metal or radioactive toxicity of the water in the area (small streams and ponds) since some of the health disorders were more in the people staying near these water sources. Several national and international groups conducted health and toxicological studies between 1998 and 2002 and arrived at the conclusion that the abnormal health problems at Kasargod were due to the spraying of Endosulfan. The commonly noted unusual diseases were neurobehavioral disorders, congenital malformations in girls and abnormalities of reproductive tract in males. Another report showed increased rate of cancers and gynecological abnormalities as well. Later the Kerala State health department also conducted medical camps in various regions and subsequently conducted a study. The report reaffirmed the relationship between Endosulfan and the health problems in Kasargod. A study conducted by National Institute of Occupational Health (NIOH) on the health hazards of Endosulfan spraying on Kasargod in 2001 had found that the pesticide Endosulfan is the cause of number of health problems among children living in the exposed area. These children had significantly lower intelligence level and very high incidence of various sexual disorders. Even blood samples of young children had deadly residues of the pesticides. Domestic animal such as cattle also became the victims of the deadly pesticides. In 2002 the Kerala High Court banned the sale and use

of Endosulfan in Kerala, and following this the State Government also issued a ban order in 2003. Local efforts for relief and rehabilitation started at Kasargod with the help of the local panchayath, local organizations and the Calicut Medical College in 2003. Facilitated by Thanal (group of nature enthusiasts who are against the use of pesticides) and the Kasargod District Panchayat, a consultative workshop was conducted in August 2005. It was attended by various health experts and social workers to formulate a plan to bring the relief and remuneration package to the victims.

The Endosulfan Victims Relief and remediation Cell is the outcome of the consultative workshop held in 2005. Several studies conducted later did reveal the links between the diseases and the Endosulfan spraying. Dr. Mohan Kumar and Dr. Sripathi Kajampady have a better picture of the disease trends there because of their long association with people in the area.



Ians (2012) The New India Express

1.1.5: Endosulfan Poisoning In Muthalamada, Palakkad, Kerala.

Even three years after the global ban on killer pesticide Endosulfan, Muthalamada, known as the Mango City of the State, turns to be a toxic hub because of heavy use of pesticide ENDOSULFAN by some mango farmers. Mangoes worth Rs. 200 crore are exported from Muthalamada every season. Muthalamada has mango orchards spread over

20,000 acres. During February-June every year, Muthalamada would bustle with activity as scores of mango pickers emerge from outside. Muthalamada produces almost all the best and most sought after varieties of mangoes in India. -Alphonso, Neelam, Mallika, Malgova and Chenthooram. Here the pesticide Endosulfan is sprayed on trees with the nozzle of the pump directed skywards. The person engaged in spraying gets affected almost instantly. Endosulfan is the cheapest among all pesticides. It costs less than Rs. 100 a liter; where one liter is enough for an acre. The spraying begins in January and is done manually by farm workers without protective gear. Unlike Kasargod where helicopters were used to spray Endosulfan, here the pesticide is sprayed to individual tree with nozzles directed skywards. Most of the farmers do not know the deadly impact of the pesticides on their life and also they don't take any precautionary measures such as masks, gloves, etc. Despite the campaign for organic farming practices, a number of farmers buy chemical pesticides in large quantities from Pollachi, a nearby town to Kerala. Huge cans of pesticides without label are brought from Pollachi to mango farms here at the instance of greedy promoters and intermediaries who influence poor farmers. Thus people living near the mango orchards at Muthalamada Panchayat are facing a number of health problems due to the use of Endosulfan pesticides.



Hemalatha, an Endosulfan victim with her mother, at Muthalamada, Near Palakkad.

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1.2 FCM Models

Fuzzy Cognitive Map is an extension of cognitive maps for modeling complex causal relationships easily, both qualitatively and quantitatively. A Fuzzy Cognitive Map (FCM) is a directed graph with concepts (policies, events etc.) as nodes and causalities as edges. The map represents relationships between concepts. If the nodes of FCM are members of fuzzy sets then they are called fuzzy nodes.

Potential applications of FCM are very broad. FCMs combine fuzzy logic and neural networks inheriting their main advantages. They gained momentum due to their dynamic characteristics and learning capabilities. These capabilities make them essential for modeling and decision making tasks as they improve the performance of these tasks. In this research work different fuzzy models are used to analyse the problem under consideration. They are Combined Effective Time Dependent (CETD) Matrix, Fuzzy cognitive maps (FCMs), Combined Fuzzy cognitive maps (CFCMs), Induced fuzzy cognitive maps (IFCMs) and the newly introduced model Maximum Fuzzy cognitive maps (MFCMs).

Definition 1.2.1: Average Time Dependent (ATD) Matrix

From the initial raw data, a matrix is obtained by taking along the rows, the age group and along the columns, the victims of the social problem. Using the raw data matrix we make it into the Average Time Dependent Data (ATD) matrix (a_{ij}) by dividing each entry of the raw data matrix by the number of year's i.e the time period. A simple average technique is used to convert the above ATD matrix to a new matrix called Refined Time Dependent (RTD) Matrix, with entries e_{ij} . The value of the e_{ij} corresponding to each entry is determined in a special way.

Definition 1.2.2: Refined Time Dependent (RTD) Matrix

Using the average μ_j and the S.D σ_j of each j^{th} column of ATD matrix with a parameter α from the interval $[0, 1]$ the Refined Time Dependent (RTD) Matrix is derived by using the following formula:

$$\begin{aligned} &\text{if } a_{ij} \leq (\mu_j - \alpha \sigma_j) \text{ then } e_{ij} = -1 \text{ else} \\ &\text{if } a_{ij} \in (\mu_j - \alpha \sigma_j, \mu_j + \alpha \sigma_j) \text{ then } e_{ij} = 0 \text{ else} \\ &\text{if } a_{ij} > (\mu_j + \alpha \sigma_j) \text{ then } e_{ij} = 1 \end{aligned}$$

A row sum matrix is calculated for every α by adding entries of each row, which gives the number of people belonging to the age group. A graph depicting the maximum age group drawn against age groups to the number of victims belonging to the age group.

Definition 1.2.3: Combined Effective Time Dependent Data (CETD) Matrix

Combining the above RTD matrices for different $\alpha \in [0, 1]$, the Combined Effective Time Dependent Data (CETD) matrix is obtained which gives the cumulative effect of all the RTD matrices. The row sum is obtained for CETD matrix and conclusions are derived based on the row sums. All these are represented by graphs and graphs play a vital role in exhibiting the data by the simplest means.

Fuzzy Cognitive Maps (FCMS)

Definition 1.2.4:

Fuzzy Cognitive Maps (FCMs) are digraphs that capture the cause/effect relationship in a system. Nodes of the graph stand for the concepts representing the key factors and attributes of the modeling system, such as inputs, variable states, components factors, events, actions of any system. Signed weighted arcs describe the casual relationships, which exists among concepts and interconnect them, with a degree of causality. The constructed graph clearly shows concepts influence each other and how much the degree of influence is. Cognitive Maps (CMs) were proposed for decision making by Axelrod (1972) for the first time. Using two basic types of elements; concepts and casual relationship, the cognitive. Map can be viewed as a simplified mathematical model of a belief system. FCMs were proposed with the extension of the fuzzified casual relationships. Kosko(1986), introduced FCMs as fuzzy graph structures for representing casual reasoning. When the nodes of the FCM are fuzzy sets then they are called fuzzy nodes. FCMs with edge weights or causalities from the set $\{-1, 0, 1\}$ called simple FCMs. Consider the nodes/concepts $P_1, P_2, P_3, \dots, P_n$ of the FCM. Suppose the directed graph is drawn using edge weight e_{ij} from $\{-1,0,1\}$. Suppose casual edge is classically fuzzy ie, Suppose it takes values in the unit interval , then construction of fuzzy adjacency in matrices proceeds by replacing e_{ij} with a casual indicator function which is 1 if $e_{ij} > 0$ and 0 if $e_{ij} \leq 0$.

Definition 1.2.5: The matrix M be defined by $M = (e_{ij})$ where e_{ij} is the weight of the directed edge $P_i P_j$. M is called 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 real interval $[-1, 1]$. $e_{ij} = 0$ indicates no causality. $e_{ij} > 0$ indicates casual increase/positive causality. $e_{ij} < 0$ indicates casual decrease/negative causality. Simple FCMs provide quick first-hand information to an expert's stated casual knowledge. Let $P_1, P_2, P_3, \dots, P_n$ be the nodes of FCM. Let $A = (a_1, a_2, \dots, a_n)$ is called a state vector where either $a_i = 0$ or 1. If $a_i = 0$, the concept a_i in the OFF state and if $a_i = 1$, the concept a_i in the ON state, for $i = 1, 2, \dots, n$. Let $P_1 P_2, P_2 P_3, \dots, P_i P_j$ be the edges of the FCM ($i \neq j$). Then the edges form a directed cycle.

Definition 1.2.6: An FCM is said to be cyclic if it possesses a directed cycle. An FCM with cycles is said to have a feedback, when there is a feedback in an FCM, i.e., when the casual relations flow through a cycle in a revolutionary 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. Inference from the hidden pattern summarizes the joint effects of all interacting fuzzy knowledge.

Definition 1.2.7: Suppose $A = (a_1, a_2, \dots, a_n)$ is a vector which is passed into a dynamical system E . Then $AE = (a'_1, a'_2, \dots, a'_n)$ after thresholding and updating the vector suppose we get (b_1, b_2, \dots, b_n) . We denote that by $(a'_1, a'_2, \dots, a'_n) \hookrightarrow (b_1, b_2, \dots, b_n)$. Thus the symbol ' \hookrightarrow ' means the resultant vector has been threshold and updated.

Definition 1.2.8: Finite number of FCMs can be combined together to produce the joint effect of all FCMs. Let E_1, E_2, \dots, E_p be the adjacency matrices of all FCMs with nodes i.e. Combined FCMs denotes the relational matrix by $E = E_1 + E_2 + \dots + E_p$.

1.2.9 Implementing FCM Model:

From the questionnaire, some of the factors are selected as indicators with great care for the study. These indicators are identified as concepts C_1, C_2, \dots, C_n . A directed graph and the connection matrix $M = (a_{ij})$ of FCM are formulated with $a_{ij} = 0$, if $C_i \Rightarrow C_j$ and $a_{ij} = 1$, if

$C_i \Rightarrow C_j$. A state vector is defined such that, one concept C_i (say) is in “ON” state and the remaining are in “OFF” states. Accordingly as the vector P_1^i having 1 in i^{th} place and 0 in other places is introduced and the product $P_1^i M$ of P_1^i and M is calculated. The resulting vector P_2 is modified or threshold by assigning 1 if the values of the entries are >1 . Then $P_2 M$ is calculated and modified at each stage until the two consecutive vectors become equal. Finally the fixed point having some entries 1 and the remaining 0 is obtained. The concepts corresponding to the entries having 1 in the fixed vector are impactful for the concept C_i in the state vector P_1^i .

1.2.10 Induced Fuzzy Cognitive Maps (IFCMS)

Even though IFCM is advancement of FCM it follows the foundation of FCM, it has a slight modification only in Algorithmic approaches. To derive an optimistic solution to the problem with an unsupervised data, the following steps to be followed:

Algorithmic Approach in IFCM

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 in the given matrix = number of steps to be performed.

Step 4: Consider the state vector P_1^i by assigning the first component of the vector to be 1 and the rest of the components as 0. Find $P_1^i \times M$ and is denoted P_2

Step 5: Now each component in the P_2 vector is taken separately and 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 as Q_2 .

Step 6: Product of Q_2 and M is calculated and its modified by assigning 1 if the values of the entries are >1 . Let the modified vector be Q_2

Step 7: Repeat step 5, when the same threshold value occurs twice. The value is considered as the fixed Point. The iteration gets terminated.

Step 8: Continue Step 1 to 7 for all the state vectors and find hidden pattern.

Definition 1.2.11: Maximum Fuzzy Cognitive Maps (MFCMs)

MFCM is an advancement of FCM which follows the foundation of FCM. It has a slight modification only in algorithm approaches which are different from IFCM. The following steps are used for finding MFCM.

- Step 1 : For the given model (problem) collect the unsupervised data that is in determinant factors called nodes or concepts
- Step 2 : According to the expert opinion, draw the directed graph depicting interrelationship between the concepts
- Step 3 : Obtain the connection matrix, M , from the directed graph (FCM). Here the number of rows in the given matrix = number of steps to be performed.
- Step 4 : In the connection matrix M , choose the row having maximum number of 1's occurs first and call it R_1 vector.
- Step 5 : Now each component in the R_1 vector is taken separately and the product of the given matrix is calculated and threshold at each stage by assigning 1 if the value of the entry is ≥ 1
- Step 6 : From the result the vector which has the maximum number of one's occurring first is considered as R_2 . Find $R_2 \times M$ and the vector is updated and threshold s in step 5. . It is named as R_2
- Step 7 : Repeat step 5 till the same threshold value occurs twice, and the value is considered as the fixed point. The iteration gets terminated.