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A FUZZY TOPOLOGY FOR OPERATOR IN SPATIAL OBJECT QUANTITATIVELY IN FLOOD PREDICTION

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ABSTRACT

For the time being in GIS application fuzzy spatial objects have become extremely important. There have been many research developments on the conceptual description of the topological relation between spatial objects. In this paper a formal definition of the computational fuzzy topology is shown which is based on the interior operator and closure operators. In spatial object modeling the interior and exterior boundary are computed based on computational fuzzy topology. An example for determining interior boundary and exterior boundary of the flood affected area of Chennai based on data collected from Integrated Multi-Satellite Retrievals for GPM, a Global Precipitation Measurement Mission.

KEYWORDS: Fuzzy Topology; Fuzzy Spatial Objects; Closure Operator; Interior Operator.

1. INTRODUCTION

The topological relation between spatial objects is used in geographic information system with position and attribute information. Information on topological relations can be used for spatial queries, spatial analysis data quality control (e.g. Checking for topological consistency) and others. Topology relations can be crisp or fuzzy depending on the certainty or uncertainty of spatial objects and the nature of their relations. Originally in the modeling of spatial objects, such as rivers, roads, trees, and building in GIS, it was normally assumed that the measurement of the spatial objects was free of errors. But in reality the description of the spatial objects in GIS contains some uncertainties, such as random errors in measuring spatial objects or vagueness in interpreting the boundaries of nature. For example vagueness or fuzziness in the boundary between states or between urban and rural areas is difficult to describe by traditional GIS. Therefore, there is a need to enhance existing GIS's by further copying with the uncertainties in spatial objects and the topological relation between uncertain spatial objects. Thus the classical set theory which is based on a crisp boundary, may not be fully suitable for handling such problem of uncertainty. On the other hand, fuzzy sets provide a useful tool to describe the uncertainty of a single object in GIS.

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The fuzzy set introduced by Zadeh in the year of 1965. Fuzzy theory has been developed since 1996 and the theory of fuzzy topology has been developed based on the fuzzy set. Fuzzy topology theory can potentially be applied to the modeling of fuzzy topological relations among spatial objects. There are two stages of modeling fuzzy topological relation among spatial object (a) to define and describe spatial relations qualitatively and (b) to compute the fuzzy topological relations quantitatively. For the first stage of modeling fuzzy spatial relations with a number of models have been developed which can provide a conceptual definition of the uncertain topological relation between spatial objects based on descriptions of the interior boundary and exterior of spatial objects in GIS. And for the second stage of the modeling of uncertain topological relations, for instance to compute the membership values of interior boundary and exterior of a spatial object based on fuzzy membership function.

In this paper by collecting the real world data set we apply the developed method to GIS to compute the interior, closure and boundary of spatial objects and analysis of the model to derive the topological relation between spatial object and also we apply e-continuous function and e-open set in Fuzzifying Topology to GIS.

2. FUZZY TOPOLOGY

Definition 2.1 (Fuzzy sets and fuzzy topology [3])

A fuzzy set of X is a function with domain X and value in I, that is an element of I^X. Let $\lambda \in I^X$. The subset of X in which λ assumes non-zero values in known as the support of λ. For every $x \in X, \lambda(x)$ is called the grade of membership of x in λ. X is called the carrier of the fuzzy set λ. If λ takes only the values 0 and 1, then λ is called a crisp set in X.

Let $\lambda, \beta \in I^X$, we define the following fuzzy sets.

1. $\lambda = \beta$ if $\mu_\lambda(x) = \mu_\beta(x)$, for all x in X.
2. $\lambda \leq \beta$ if $\mu_\lambda(x) \leq \mu_\beta(x)$, for all x in X.
3. $\gamma = \lambda \vee \beta$ if $\mu_\gamma(x) = max\{\mu_\lambda(x), \mu_\beta(x)\ for\ all\ x\}$
4. $\lambda \wedge \beta \in I^X$ by $(\lambda \wedge \beta)(x) = min\{\lambda(x), \beta(x),$ $for\ every\ x \in X\ (intersection)$.

Fuzzy sets, open fuzzy sets and closed fuzzy sets are the basic elements of fuzzy topology. In the following, we introduce the concept of fuzzy topology.

Definition 2.2 (Fuzzy topological space [3])

Let X be a non empty ordinary set and $I = [0,1]$, $\delta \subset I^X$, δ is called a I-fuzzy topology on X, and (I^X, δ), is called I-fuzzy topological space (I-fts), if the following conditions:

1. $0,1 \in \delta$;
2. If $\lambda, \beta \in \delta$, then $\lambda \wedge \beta \in \delta$.
3. Let $\{\lambda_i : i \in I\} \subset \delta$, where I is an index set, then $\vee_{i \in I} \lambda_i \in \delta$.

Where $0 \in \delta$ means the empty set and $1 \in \delta$ means the whole set X. The elements in δ are called open elements and the elements in the component of δ are called closed elements and the set of the complement of open sets is denoted by δ.

Definition 2.3 (Interior and Closure [3])

For any Fuzzy set λ, defined by the interior of λ the joining of all the open subsets contained in λ, denoted by, $\lambda°$ i.e. $\lambda° = \vee \{\beta \in \delta; \beta \leq \lambda\}$, and the closure of λ as the meeting of all the closed subsets containing λ, denoted by $\bar{\lambda}$, i.e. $\bar{\lambda} = \wedge \{\beta \in \delta' : \beta \geq \lambda\}$, and the exterior of λ is the complement of the closure of λ.

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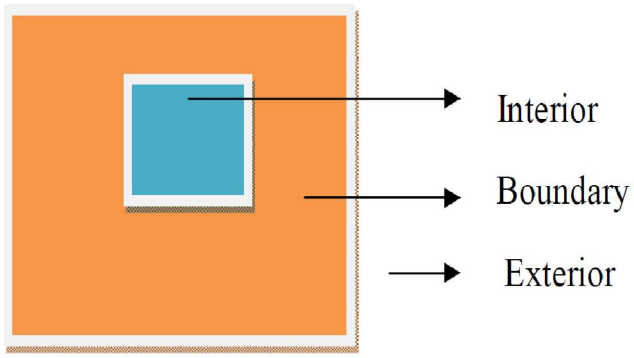


Definition 2.4 (Fuzzy complement)

For any fuzzy set λ by defining the complements of λ by $\lambda'(x) = 1 - \lambda(x)$.

Definition 2.5 (Fuzzy boundary)

The boundary of a fuzzy set λ is defined $\delta\lambda = \bar{\lambda} \wedge \bar{\lambda}^C$.

Definition 2.6 (Closure Operator)

An operator $\alpha: \mathbb{I}^X \to \mathbb{I}^X$ is a fuzzy closure operator if the following conditions are satisfied:

(i) $\alpha(0) = 0$,
(ii) $\lambda \leq \alpha(\lambda)$, for all $\lambda \in \mathbb{I}^X$,
(iii) $\alpha(\lambda \vee \beta) = \alpha(\lambda) \vee \alpha(\beta)$,
(iv) $\alpha(\alpha(\lambda)) = \alpha(\lambda)$, for all $\lambda \in \mathbb{I}^X$.

Definition 2.7 (Interior Operator)

An operator is a fuzzy closure operator if the following conditions are satisfied

(i) $\alpha(1) = 1$
(ii) $\alpha(\lambda) \leq \lambda$, for all $\lambda \in \mathbb{I}^X$,
(iii) $\alpha(\lambda \wedge \beta) = \alpha(\lambda) \wedge \alpha(\beta)$,
(iv) $\alpha(\alpha(\lambda)) = \alpha(\lambda)$, for all $\lambda \in \mathbb{I}^X$.

Definition 2.8 (e–Continuous [18])

A function $f: X \to Y$ is said to be Fuzzy e–continuous [18] if the inverse image of every open fuzzy set in Y is e–open fuzzy set in X.

Definition 2.9 (e-Open [19])

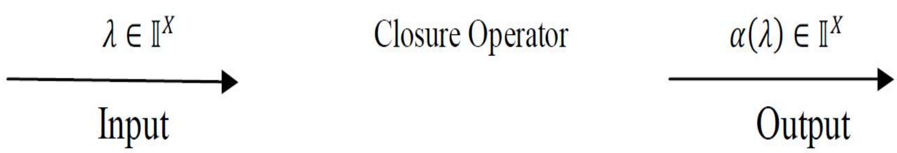
A fuzzy set λ in a fuzzy topological space X is said to be Fuzzy e-open sets [19] if $\lambda \leq int(cl_\delta(\lambda)) \vee cl(int_\delta(\lambda))$.

Definition 2.10 (e-Preopen [20])

A fuzzy set λ in a fuzzy topological space X is said to be Fuzzy Preopen set [20] if $\lambda \leq int(cl(\lambda))$.

3. FUZZY TOPOLOGY INDUCED BY THE INTERIOR AND CLOSURE OPERATIONS

The each interior operator corresponds to one fuzzy topology and each closure operator corresponds to one topology. In general two operators, interior and closure, separately they will define to fuzzy topologies, respectively. These two topologies may not cohere to each other. The following two definitions are about the interior and closure operators which are coherent with each other in defining fuzzy topology.



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Interior operator on X defined open sets δ and closed sets by taking complement δ' is called a coherent fuzzy topology (X,δ,δ'). Closure operator on X defined by closed sets τ' and open sets by taking complement τ is called a coherent fuzzy topology (X,τ,τ'). Interior operator on X and the Closure operator defined by the open sets δ if and only if closed sets by taking complement δ' is called a coherent fuzzy topology (X,δ,δ').

Definition 3.1 (Interior and Closure operators)

Let λ be a fuzzy set in $[0,1]^X = I^X$ for any fixed $\alpha \in [0,1]$, by defining the interior and closure operators on $[0,1]^X = I^X$, as

$\lambda \overset{\alpha}{\rightarrow} \lambda_\alpha \in I^X$ and

$\lambda \overset{\bar{\alpha}}{\rightarrow} \lambda^\alpha \in I^X$ Respectively

Where the fuzzy sets λ_α and λ^α in X are defined by

$$\lambda_\alpha(X) = \begin{cases} \lambda(X) \; if \; \lambda(X) \; > \alpha \\ 0 \quad if \; \lambda(X) \; \le \; \alpha \end{cases}$$

$$\lambda^\alpha(X) = \begin{cases} 1 \quad if \; \lambda(X) \; \ge \alpha \\ \lambda(X) \; if \; \lambda(X) \; \le \alpha \end{cases}$$

Definition 3.2

For $0 < \alpha < 1$, define $\tau^\alpha = \{\lambda^\alpha : \lambda \in \mathbb{I}^X\}$, and $\tau_\alpha = \{\lambda_\alpha : \lambda \in \mathbb{I}^X\}$.

Proposition 3.3

The triple $(X,\tau_\alpha,\tau^{1-\alpha})$ is an I-fuzzy topological space, where τ_α is the open sets and $\tau^{1-\alpha}$ is the closed sets that satisfy $(\lambda_\alpha)^c = (\lambda^c)^{1-\alpha}$, i.e., the complement of the elements in the τ_α Closed set.

Proof.

$0^{1-\alpha} = 0 = 0_\alpha$, and $1^{1-\alpha} = 1 = 1_\alpha$, where o and 1 are elements of τ_α, and $\tau^{1-\alpha}$. That $(\wedge_{i\in\wedge} \lambda_i)_\alpha = \wedge_{i\in\wedge} (\lambda_i)_\alpha$, where $\wedge$ is finite and that the finite intersection of δ is also in δ. Finally, $(\vee_{i\in\wedge} \lambda_i)_\alpha = \vee_{i\in\wedge} (\lambda_i)_\alpha$, that the union of δ is also inδ.

4. FUZZY BOUNDARY AND INTERSECTION THEORY

In ordinary topology defined by a topology the boundary of a set λ is defined as the intersection of the closure of λ with the closure of the complement of λ. That is, $\delta\lambda = \bar{\lambda} \wedge \left(\overline{\lambda^c}\right)$. On the other hand it has a equivalent definition that is $\delta\lambda = \bar{\lambda} - \lambda^\circ$. Uniformly, the later is no longer true in fuzzy topology. However to be consistent with the previous studies, we adopt the former as the definition of fuzzy boundary.

Definition 4.1 (Fuzzy Boundary)

For $1 \ge \alpha > 0$, define the boundary of a fuzzy set λ in a fuzzy topology $(X,\tau_\alpha,\tau^{1-\alpha})$ as$\delta\lambda = \lambda^{1-\alpha} \wedge (\lambda^c)^{1-\alpha}$.

AN EXAMPLE OF COMPUTING THE INTERIOR, BOUNDARY, AND EXTERIOR OF SPATIAL OBJECTS

For a general fuzzy topology, even if have the membership function of a fuzzy set only get the abstract definitions of interior, boundary, and closure rather than the formula for computing them. With these definitions, we cannot practically use these abstract definitions for topological calculations, or for other applications. For the fuzzy topology induced by these two operators, the interior operator and closure operator are defined based on formulae. That is, if we have the formula of a fuzzy set, then the interior and closure of this fuzzy set can be computed by using the natural definitions of these two operators. Hence, the other parts that included the boundary and exterior can be computed directly. In this section, we try to demonstrate how to compute the interior, closure, and boundary of spatial objects for real GIS data, using an example.

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OBSERVED RAINFALL

The city of Chennai and its suburb areas recorded multiple torrential rainfall events during November-December 2015 that inundated the coastal districts of Chennai, Kanchipuram and Thiruvallur. Those affected more than 4 million people with economic damages that cost around US$3 billion. There was very heavy rainfall on November 8, 9, 12, 13, 15, 23, and December 1. During the 24 hours ending 8:30 a.m. on December 2, 2015, "extremely heavy rainfall" was reported in Chennai. According to statistics it is recorded as follows:

- 49 cm at Tambaram in Kanchipuram district,
- 47 cm at Chembarambakkam in Thiruvallur District,
- 42 cm at Marakkanam in Thiruvallur District,
- 39 cm at Chengalpattu in Kanchipuram district,
- 39 cm at Ponneri in Thiruvallur District,
- 38 cm at Sriperumbudur in Kanchipuram district,
- 38 cm at Cheyyur in Kanchipuram district,
- 35 cm at Chennai airport,
- 34 cm in Mamallapuram, Poonamallee, Red Hills and Chennai city.
- 28 cm being the lowest rate is recorded in Taramani, Cholavaram, Thamaraipakkam and Madurantakam.

According to the United States National Aeronautics and Space Administration's (NASA's) Integrated Multi-Satellite Retrievals for Global Precipitation Measurement or GPM (IMERG), from November 29 to December 2 over 400 mm of rainfall fell over areas south of Chennai.

The Adyar River originates from a tank near Manimangalam village in Sriperumbudur in Kanchipuram district, but it is only when the water from Chembarambakkam lake joins the river that the stream appears. The river then flows through Tiruvallur and Chennai and flows into the Bay of Bengal at Adyar in Chennai. Chembarambakkam lake is a rain – fed reservoir which supplies water to Chennai city through Pipelines. When the lake's water flows over capacity, the excess is released into the Adyar river, releasing excess water into the river is important, because if that is not done, then the lake walls could breach, leading to an uncontrolled flow of water into the Adyar and thus Chennai city. The lake can hold water up to a maximum level of 24 feet (the measure which is used to indicate the amount of water) with a full capacity of 3645 million cubic feet, which has a full tanks level of 24 feet and discharging capacity of 33,000 cubic feet per second water levels began rising in different parts of the city and the situation looked grim.

The authorities released 10,000 cusecs of water at 10 a.m.
The authorities released 12,000 cusecs of water at 12 p.m.
The authorities released 21,000 cusecs of water at 2 p.m.
The authorities released 25,000 cusecs of water at 5p.m.

The water levels in the dam were rising close to dangerous levels and by 10 p.m. the water released was flowing at about 29,000 cusecs or 320,000 liters per second into the Adyar River. This water would travel 25 kilometers in darkness, making the river swell and good everything in an area of over 4 kilometers from its bank. What aggravated the situation further was that the surging waters from different tanks and reservoirs.

Which flowed into the Adyar River had breached their embankments and added to the spates. Submerging many low lying localities, which were in the flood basin. What made matters worse was that the water was released from the two other reservoirs.

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Poondi and Puzhal into the Cooum River adding to the flooding in different parts of the city. The flooding was widespread, but some of the neighborhoods which faced the worst flooding were situated where the river banks, including Jaffarkhanpet, Saidapet, Kotturpuram, Adyar and the Chennai airport which is built in the Adyar flood basin. Areas like Vadapalani, Valasaravakkam, Velachery, Madipakkam, Tambaram, Mudichur and Urapakkam were badly affected.

ATMOSPHERIC CONDITIONS DURING THE EXTREME RAINFALL EVENT

The extreme high intensity rainfall event that occurred over Chennai was an outcome of a depression generated over a warm Bay of Bengal, which brought huge moisture from the Bay of Bengal and resulted in heavy precipitation over the South – East coast of India. The spatial distribution of Mean Sea level Pressure (MSLP) till November, 27, 2015 shows a wide spread low pressure over the South of Bay of Bengal, which became concentrated over Sri Lanka and brought huge moisture over the Chennai region on December. Mean trough low pressure and in having an elongated low pressure area. So, slow moving, weak cyclonic disturbances. If they are stationary they give bountiful rain even if take the winds also strong winds were there on that day they were coming the Tamil Nadu coast. More than 50kmph, so kilometers per but once it comes closer to Tamil Nadu it becomes 35kms. So there is a reduction is speed. So this leads to the Moisture convergence. In Meteorological terms is denoted by a velocity convergency. The high perceptible water over the same region made the conditions favorable for heavy precipitation over Chennai, which 7 continued till December 2, 2015. The low MSLP remained concentrated over the same region during December 4, 2015.

IMPACT OF GLOBAL WARMING

Impact of Global Warming and Urbanization Scientific theories and model studies suggest an increase in tropical cyclones during recent decades, though these are not really very evident from the recorded number of cyclones. However, the potential destructiveness of cyclones defined as total dissipation of power, integrated over the lifetime of the cyclone has increased, is increasing and will increase in a warming environment and this is primarily associated with the warming of SST.

Bay of Bengal is attributed to the global warming, which is hypothesized to be a potential cause of the extreme event in Chennai. Extreme in Southern and Central Region of India is observed to be affected by urbanization during summer monsoon. Season; though the specific impacts during winter monsoon and cyclones have not yet been explored. Chennai is reported to have a significant urban heat island and there is a possibility of such UHI-extremes link.

Global warming has also played a larger role in the rains. 2015 was the hottest year on Record Ocean temperatures had raised by 0.85° from the 20^{th} century average of 15.9 in the month of October, and 2015 El-Nino one of the worst on record.

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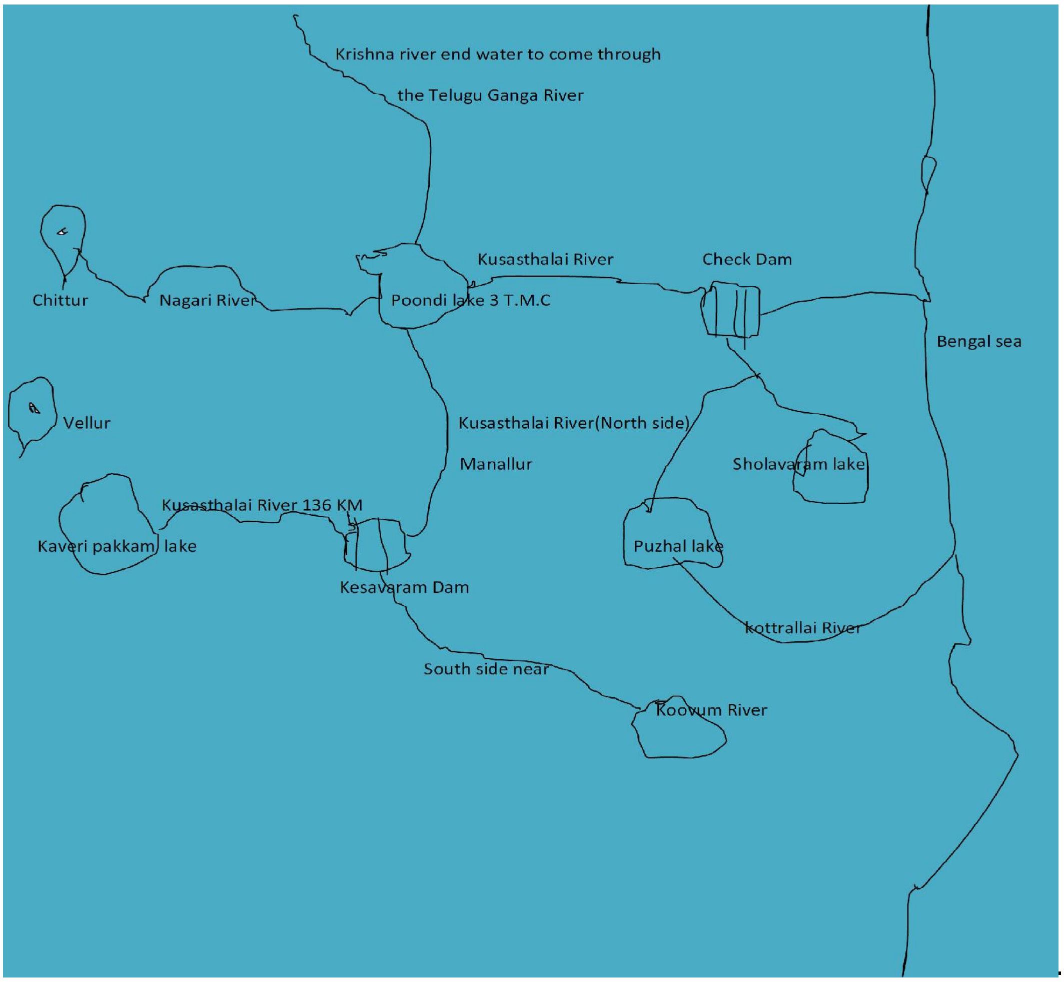
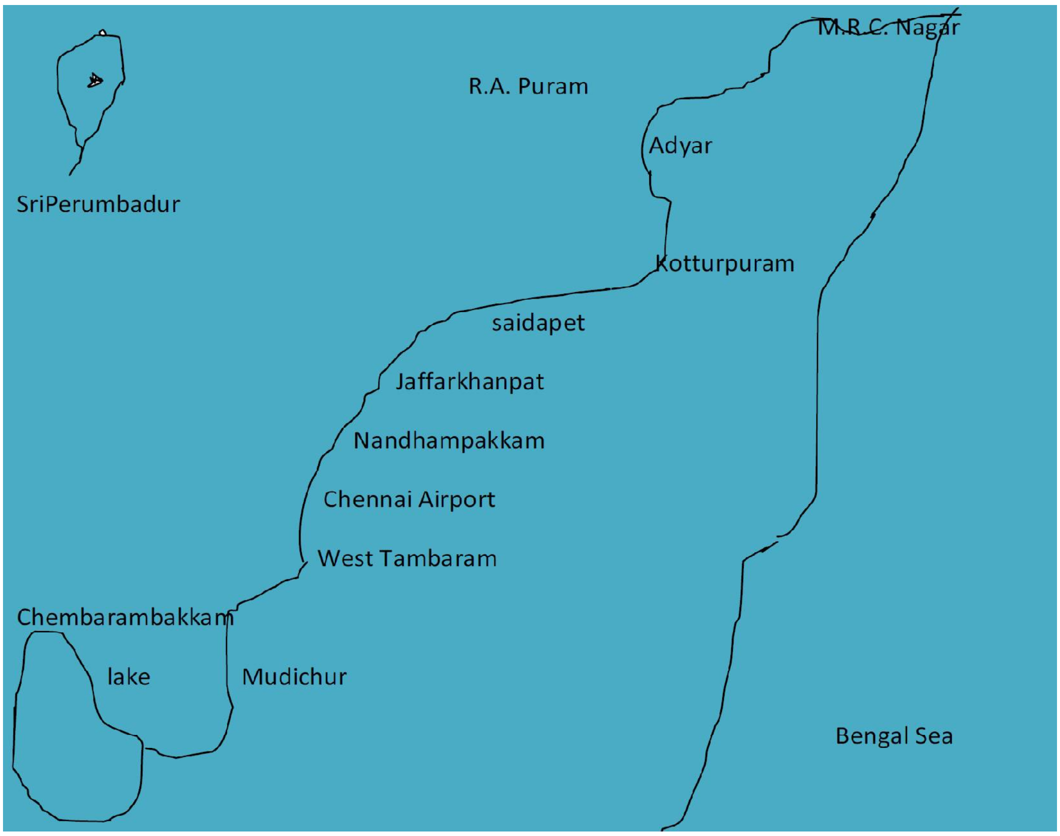
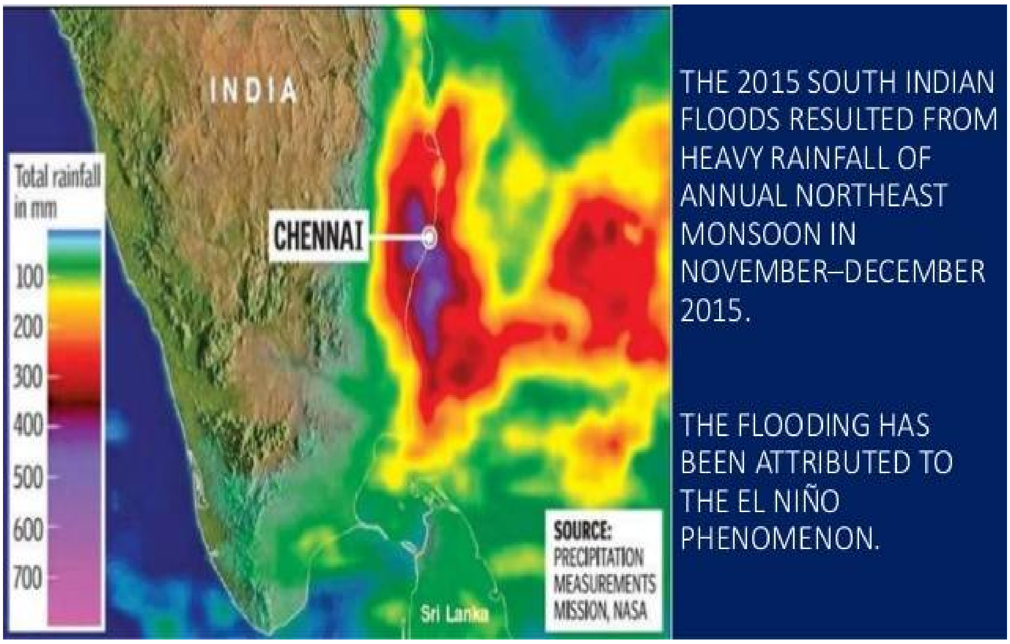

Krishna river end water to come through
the Telugu Ganga River
Kusasthalai River
Check Dam
Chittur
Nagari River
Poondi lake 3 T.M.C
Bengal sea
Vellur
Kusasthalai River(North side)
Manallur
Sholavaram lake
Kusasthalai River 136 KM
Kaveri pakkam lake
Puzhal lake
Kesavaram Dam
Kottrallai River
South side near
Koovum River


M.R.C. Nagar
R.A. Puram
Adyar
SriPerumbadur
Kotturpuram
saidapet
Jaffarkhanpat
Nandhampakkam
Chennai Airport
West Tambaram
Chembarambakkam
lake
Mudichur
Bengal Sea

EFFECT OF EL-NINO

EL-Nino is a weather phenomenon resulting in warmer than normal ocean temperatures in the Pacific Ocean it impacts the north east monsoons in India and is often believed to bring a good amount of rainfall. The impact of EL-Nino a strong storm cloud formation and easterly winds would soon descend upon Chennai. The EL-NINO of 2015 was one of the strongest reported, which started developing in 2014 EL-Nino is reported to have impacts on North East Monsoon by modestly intensifying it. A possible hypothesis would be that a stronger EL-Nino led to a strong easterly during November- December 2015 which probably brought moisture to the East coast of India over Chennai with a much intensified rainfall.



GEOGRAPHICAL AND METEOROLOGICAL EXPLANATION

From October to December each year, a very large area of South India, including Tamil Nadu, the coastal regions of Andhra Pradesh and the union territory of Puducherry, receive up to 60 percent of its annual rainfall from the northeast monsoon (or winter monsoon). The northeast monsoon is the result of the annual gradual retreat of monsoonal rains from northeastern India. Unlike during the regular monsoon, rainfall during the northeast monsoon is sporadic, but typically far exceeds the amount produced by the regular monsoon by up to 90 percent. This excessive rainfall can be exacerbated by an EL-Nino of the order of the magnitude which has since been evaluated to every year, such as 2015. The coast of Andhra Pradesh usually bears the brunt of heavy rains that occur during the northeast monsoon with numerous river systems and wetlands, Puducherry and eastern Tamil Nadu are prone to flooding. The city of Chennai alone experienced five major floods between 1943 and 2005, with the 1943, 1978 and 2005 floods causing particularly severe damage. In addition, unplanned and often illegal urban development has led to many wetlands and natural sinks being built over, this along with ageing civic infrastructure and poorly designed drainage systems has resulted in an increased frequency of severe flooding.

ANALYSIS OF CAUSES

Unregulated urban planning and illegal construction and Improper design and maintenance of drainage systems and Climate – change related

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RESULTS OR POSSIBLE SOLUTIONS FROM DEVELOPED COUNTRIES

The Chembarambakkam Lake is one of the city's water sources. The level of water in the reservoir is required to be maintained of 2 feet below the full tank level, While the monsoon is still active. This ensures that there is no water scarcity in the shortage period as well as flood control and safety of the dam. When dams are constructed they are multi-purpose reservoirs. Constructed for irrigation, drinking water and flood control. The general guiding principle is that 1/3 of the water is kept in lead storage, 1/3 for water supply, and 1/3 for storing flood waters. But because India is drought prone, it is generally felt that 80% should be kept for water supply and 20% of flood water storage. Chennai is very flat so the water doesn't drain only through channels, it also drains across the landscape, and if we reduce the capacity of all these water bodies. Global surface temperatures have risen by nearly 1° in the past century. Global sea levels have risen almost 4 inches to 8 inches caused by different factors linked to a –going global warming putting coastal countries at high risk.

Since the beginning of the 21st century Asia has experienced 550 flooding events which have affected 850 million people in Asia. Flooding currently affects 21 million people on average in a year. India has 7 major rivers with hundreds of smaller rivers and a 7, 500 kilometer Coastline, making it vulnerable to flooding. India has about 340 million people living in cities a number expected to almost double by 2030. Dense population is cities creates the urban heat – island effect where the temperatures are hotter than the rural surrounding areas whenever rain-bearing clouds pass over these areas the hot air pushes the clouds up resulting in highly localized rainfall. Which may sometimes be high intensity. Checking the drainage systems in India tops the list of 163 nations most affected by river floods, according to the World Resources Institute. The lives of 4.85 million Indians are disrupted due to floods every year.

URBAN FLOOD PROTECTION MEASURES

THAMES BARRIER (LONDON) FROM UNITED KINGDOM

The Thames Barrier is a unique flood control structure on the River Thames at Woolwich Reach in East London. It is 520 meters wide and protects London against storm surges and rainfall swelling. Without the barrier the Houses of parliament, the O^2 arena, Tower Bridge and areas of Southwork, Beckton, West Ham, and Whitechapel would all be submerged in flood water. It took eight years to build the structure, costing £535m (£1.6 billion in today's money) and become fully operational in 1982. The Tames Barrier is the second largest flood defense barrier in the world after the Oosterscheldekering Barrier in the Netherlands.

OPERATION OF THAMES BARRIER

The barrier is a series of 10 separate movable steel gates, standing 20 meters tall and stretching 520 meters across the river. Each of the main gates is a hollow steel-platted structure over 20m high and weighing around 3,700 tonnes, capable of withstanding an overall load of more than 9,000 tonnes of water. When the barrier is closed, a solid steel wall sealing the upper part of the river from the sea is created, stopping water from flowing upstream towards the capital. The gates can also be partially closed in the under spill position, allowing a controlled amount of water to pass under the gate and up the river.

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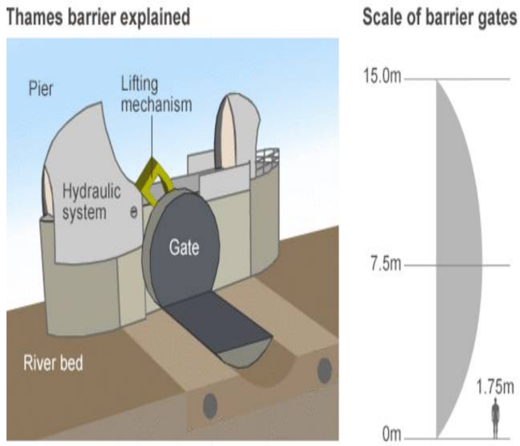

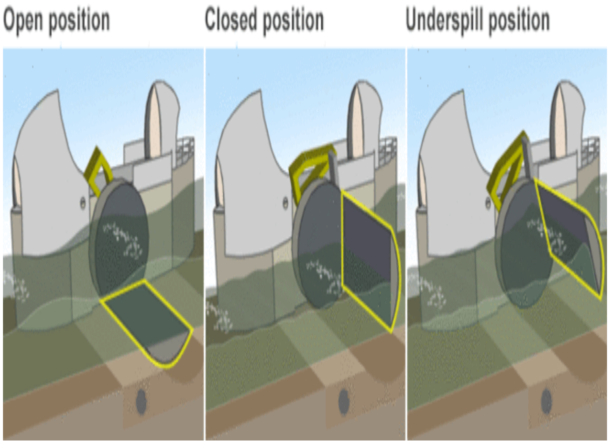

RETARDING BASIN (MELBOURNE) FROM AUSTRALIA

Retarding basins play an important function in managing storm water in your local area. They are low lying areas of land set aside to temporarily store storm water during very high rainfall. In Australia, they have a managed over 200 retarding basins across Greater Melbourne with many recreational areas for the community. They may be grassy area available for recreation while dry, or hold water permanently which supports biodiversity. When a retarding basin fills, the landscape is designed to hold back storm water to reduce flood risk to local homes and businesses. During this time, recreational areas may be affected. The stored water is then slowly released into the downstream drain or waterway.

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THE MAOUDC FROM (TOKYO) JAPAN

The Metropolitan Area Outer Underground Discharge Channel, is an underground water infrastructure project in Kasukabe, Tokyo, Japan. It is the world's largest underground flood water diversion facility, built to mitigate overflowing of the city's major waterways during heavy rain.

CONSTRUCTION TECHNOLOGY

The cylindrical shafts are about 70m tall. The large shafts measure about 30m in diameter, spacious enough to park a space shuttle. The connecting tunnel 50m below ground measures about 10m in diameter. The tunnel stretches for 6.3km, including a sharp curved line with a minimum radius of 250meters. Before being discharged into rivers, the drained water is stored in a huge pressure-controlled tank. The tank is designed to perform multiple functions, including abating the force of running water and adjusting water pressures that could change sharply if a water pump breaks down. Measuring 177m lon and 78m wide, and lying about 22m belowground, the water tank is larger than a soccer pitch. The ceiling of the water tank is supported by 59 pillars which are 18 m tall and weigh 500 tons each.

CASE STUDY

In this section a case study to compute the interior boundary, and exterior of spatial objects has been carried out. The aim of this case study is to determine the flood affected area of Chennai Each area affected by the flood is recorded. The level of any area affected by the flood is marked by a percentage level within the interval [0, 1]. For a particular value of α, we try to determine the interior, closure and boundary of each area affected by the flood. For the interior, if the value is 1, this means the effect is high in relation to the overall effected area. If the value is closure zero, this means that the effect is low in relation to the overall affected areas. The objective of this paper is to classify the fuzzy interior boundary and exterior of spatial objects for real GIS date of the area affected by flood using a new model.

ASSUMPTION

(I) Each land photo is shown as a fuzzy space.

(II) The size of each area affected by the flood is used to calculate the fuzzy value of the fuzzy sets.

(III) The fuzzy value of each area affected by the flood is defined as

$$\begin{cases} \frac{log(Area\ of\ certain\ affected\ area)}{log(Total\ area\ of\ affected\ area)} & if\ \frac{log(0)}{log(*)} > 0, \\ 0 & otherwise. \end{cases}$$

Which is a well defined mapping from the interval $[1, \infty]$ to the interval [0, 1].

(IV) The fuzzy interior and boundary will be computed for α equal to 0.3, 0.45 and 0.6 etc. respectively.

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Table no. 1

I.D. NUMBER	AREA (m^2)	I.D. NUMBER	AREA (m^2)
1	1.24	22	10.24
2	1.53	23	10.262
3	2.23	24	10.56
4	2.31	25	12.29
5	2.74	26	12.40
6	3.06	27	12.87
7	4.3	28	12.91
8	4.57	29	14.19
9	4.88	30	15.11
10	6.73	31	15.17
11	6.9	32	15.30
12	7.23	33	15.95
13	7.26	34	29.00
14	2.53	35	29.00
15	7.58	36	38.2
16	8.16	37	38.64
17	8.72	38	39.01
18	8.78	39	39.78
19	9.66	40	49.82
20	9.97	41	68.85
21	10.01		

Total: 614.942

Average - 14.99858537

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5. DISCUSSION ON THE NEWLY DEVELOPED FUZZY TOPOLOGY MODEL

Table 2.The values of fuzzy exterior, fuzzy interior and fuzzy boundary with different values of α.

ID	AREA	FUZZY VALUE	$\alpha = 0.3$			$\alpha = 0.45$			$\alpha = 0.6$		
			Exterior	Interior	Boundary	Exterior	Interior	Boundary	Exterior	Interior	Boundary
1	1.24	0.033	0.967	0	0.033	0.969	0	.033	.967	0	.033
2	1.53	0.066	0.934	0	0.066	.934	0	.066	.934	0	0.066
3	2.23	0.12	0.88	0	0.12	.88	0	.12	.88	0	.12
4	2.31	0.13	0.87	0	0.13	.87	0	.13	.87	0	.13
5	2.74	0.16	0.84	0	0.16	.84	0	.16	.84	0	0.16
6	3.06	0.17	0.83	0	0.17	.83	0	.17	.83	0	.17
7	4.3	0.23	0.77	0	0.23	.77	0	.23	.77	0	.23
8	4.57	0.24	0.76	0	0.24	.76	0	.24	.76	0	.24
9	4.88	0.25	0.75	0	0.25	.75	0	.25	.75	0	.25
10	6.73	0.30	0.70	0.30	0.30	.70	0	.20	.70	0	.30
11	9.6	0.30	0.70	0.30	0.30	.70	0	.30	.70	0	.30
12	7.23	0.31	0.69	0.31	0.31	.69	0	.31	.69	0	.31

The table number 2 shows that for different value of α, the fuzzy exterior, interior, and fuzzy boundary are different. From the table, we can say that for the larger value of α, the size of the interior will be smaller. For α is equal to 0.3, ID no greater than 9 having nonzero value. Again for α = 0.45 ID no greater than 33 have nonzero value and for α = 0.6 ID no greater than 39 have nonzero values.

This shows that the relation between interior and size of closure are directly proportional to each other while the relation between exterior and the size of the interior are inversely proportional. Clearly this new model can be used to simplify the fuzzy interior, boundary, and exterior of fuzzy spatial object. Simplifying the fuzzy interior, boundary and exterior of this area affected by flood in Chennai in this paper is a dynamic application with GIS.

CONCLUSION

In this paper an attempt has been made to provide a solution to compute the topological relations between spatial objects. The former approaches have introduced the concept of fuzzy topology into GIS. We use the application of fuzzy topology to compute the interior, exterior and boundary of fuzzy spatial objects. A case study for classifying the fuzzy interior, exterior, and boundary of the flood affected area of Chennai has been carried out. It is found that not only we get information on fuzzy topological relations between two objects such as the value of the interior, boundary, and exterior, but a quantitative level of these topological relations between simple fuzzy regions can be obtained.

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