

模糊数学与系统成果会 论文集

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序 言

模糊(Fuzzy)数学与系统这一学科,自1965年美国著名控制论专家扎德(Zadeh)教授创立以来,就以强大的生命力扎根于世界各个角落,吸引着各国的优秀学者为之奋斗。迄今为止,模糊数学自己的公理化基础——中介数学系统已在建立,正进一步接受实践的检验并逐步得到完善。如:模糊拓扑,模糊代数、模糊测度与积分,模糊逻辑,模糊概率统计,模糊运筹学等方面的研究日新月异。模糊数学的应用,如模糊工程系统,模糊计算机系统,模糊管理决策系统,模糊经济系统,模糊社会和人文系统等研究领域捷报频传。在传统数学很少问津的领地,模糊数学开出了绚丽的花朵。

伟大的中华民族,有自立于世界民族之林的能力。忆往昔,我们的祖先在丰富世界科学宝库方面,谱写了光辉的篇章。看今朝,在向模糊领域进军,在突破模糊信息处理难关的进程中,中国学者必将取得更加辉煌的成果。为了及时总结推广“Fuzzy界”同仁们的先进经验,扩大相互间的学术交流,在巩固已有研究成果的基础上,动员中南地区,乃至全国的模糊数学理论工作者和应用工作者,把研究的锋芒直指模糊信息处理。经中国系统工程学会模糊数学与系统委员会同意,于1991年7月24日,在湖南省大庸市召开了“中南模糊数学与系统理论和应用成果交流会。”这是一次以中南地区为核心,幅射全国各地的盛会。从寄自长城内外,大江南北,天山脚下,南海之滨的篇篇学术论文来看,充分显示了我国模糊集研究队伍的雄厚实力。

本届会议共收到全国25个省、市、自治区寄来的论文180余篇,经文集审稿小组较严格地审查,优选出105篇(全文或摘要),决定正式出版会议论文集,以飨读者。在文集编辑过程中,我们始终贯彻了汪浩教授‘严格把关’和吴望名教授‘保证重点,……对模糊信息处理的重要应用的新方法,新思想的论文优先录用’的原则。

由于种种原因,许多佳作未能选入,在此深表歉意。集中必有纰漏之处,敬请读者指正。

中国系统工程学会模糊数学与系统委员会,长沙水利电力师范学院,尤其是长沙水电师院数学系和科研处,以及《模糊系统与数学》、《应用数学》、《系统工程》、《湖南教育》、《长沙水电师院学报》(自科版)、《长沙水电师院报》等报刊为会议的筹备与宣传作了大量努力,使得本次会议圆满成功,本文集得以问世。对此深表谢意。

衷心感谢:长沙水电师院暨数学系、科研处;湖南省出版局,湖南科学技术出版社对出版本文集给予的大力支持,和长沙铁道学院印刷厂的鼎力相助。

衷心感谢:汪浩教授、蔡海涛教授、邓自克教授、姜华彪讲师等同志为本文集所付出的辛勤劳动。长沙水电师院外语系廖世翘教授,王佩华讲师,数学系殷荃若老师协助编辑;数883101, 883102班的部分同学,校对书稿所做的大量工作。中国工业与应用数学学会副理事长,武汉市副市长郭友中教授派专人送来的热情洋溢的会议贺信。以及为会议和文集精心撰稿的全国“Fuzzy界”同仁们的通力合作。

新年伊始,我们把这本文集,作为薄礼奉献给在各条战线上辛勤耕耘的“Fuzzy士同仁,旨在让Fuzzy数学的灿烂理论之花,结出更加丰满的经济之果。

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ALGEBRA THEORY OF SOFT ALGEBRA*

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Just as the Boolean algebra is algebra theory of sets theory, so the soft algebra is algebra of fuzzy sets theory. When the law of the complement is replaced by De Morgan, the Boolean algebra is called a soft algebra. As a consequence the soft algebra is generalization of Boolean algebra. In this paper we shall investigate what results are held and what new results are generated in the soft algebra.

Let $L = (L, \leq, \vee, \wedge, ')$ be a distributive lattice with maximal element (denoting by 1), and minimal element (denoting by 0). Where $'$ is a unary operation on L —called the De Morgan complementation—which satisfies for all $a, b \in L$: (1) $a'' = a$; (2) $(a \vee b)' = a' \wedge b'$, $(a \wedge b)' = a' \vee b'$. Then L is called a soft algebra (or a fuzzy lattice). In this definition the condition (2) can be replaced by the equivalent condition as follows: $a \leq b \Rightarrow a' \geq b'$.

For subalgebra some results of Boolean algebra are held. But homomorphic images of maximal and minimal elements can be not maximal and minimal elements.

The product of the family of soft algebras is also a soft algebra.

1. Ideal in the soft algebra

Definition 1.1 Let L be a complete soft algebra. $\emptyset \neq E \subset L$ is called an ideal of L , iff

$$i) \ x, y \in E \Rightarrow x \vee y \in E \qquad ii) \ 0 \leq y \leq x, \ x \in E \Rightarrow y \in E.$$

When condition $i)$ is replaced by $i')$, as in the following,

$$i') \ \forall x_a \in E (a \in I) \Rightarrow \sup_{a \in I} x_a \in E,$$

Then E is called a band of L .

It is obvious that arbitrary intersection of ideals (bands) is again an ideal (band).

Definition 1.2 A soft algebra is said to be complete iff every non-empty subset $E \subset L$ has a least upper bound. Let L be a complete soft algebra, let E be a band of L . Then $\forall x \in L$ the element $Px \triangleq \sup\{y \mid 0 \leq y \leq x, y \in E\}$ is called projection of x on E .

Definition 1.3 Let L be a soft algebra. The elements $a, b \in L$ are called disjo-

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int, this will be denoted by $a \perp b$, iff $a \wedge b = 0$. Moreover if A is a subset of L define,

$$A^d \triangleq \{x \in L, x \wedge a = 0 \text{ for all } a \in A\}.$$

Proposition 1.4 Let L be a complete soft algebra. Let $E \subset L$ be a band in L . Then $\forall x, y \in L, x \perp y \Rightarrow Px \perp Py$. $x \in E \iff Px = x, x \perp E \iff Px = 0, P(x \vee y) = Px \vee Py$.

When L is complete distributive for $x_i \in L (i \in I)$, then we have $P(\sup_{i \in I} x_i) = \sup_{i \in I} Px_i, P(\inf_{i \in I} x_i) = \inf_{i \in I} Px_i$.

Proposition 1.5 Let L be a complete soft algebra satisfying complete distributive law, let $E \subset L$ be any subset in L . Then E^d is a band in L , and we have

$$(1) (\sup x'_a)' = \inf x_a,$$

$$(2) (\inf x'_a)' = \sup x_a.$$

Suppose we denote by E^d a band generated by E (i.e. E^d is a least band which contains E), then $E_1 \subset L, E_2 \subset L, E_1 \perp E_2 \Rightarrow E_1^d \perp E_2^d$.

Every set $\{x_a\}_{a \in I}$ of mutually disjoint elements of the soft algebra is called a disjoint system in L .

If $\{x_a\}_{a \in I}$ is a disjoint system in L , then define $Sx_a \triangleq \sup_{a \in I} x_a$ and it is called a disjoint union of $\{x_a\}_{a \in I}$.

Obviously we have $P(Sx_a) = S(Px_a)$.

Definition 1.6 Let L be a complete soft algebra, let $\{E_a\}_{a \in I}$ be a disjoint band's system in L . $\{E_a\}_{a \in I}$ is called a complete family of the band in L iff $\sup_{a \in I} E_a = 1$.

Obviously $1 \in E_a (\forall a \in I)$ except for $\{E_a\}_{a \in I} = \{L\}$.

Proposition 1.7 Let L be a complete soft algebra. Let $\{E_a\}_{a \in I}$ be a complete family of the bands in L . Then $\forall x \in L$, we have $x = Sx_a, x_a \in E_a$. Moreover the decomposition of x with respect of $\{E_a\}_{a \in I}$ is unique to be more precise i.e. if $x = Sx_a, x_a \in E_a (\forall a \in I)$, then $x_a = P_{E_a}x$ (Where $P_{E_a}x$ is the projection of x for E_a).

It is evident that if L is a complete soft algebra, and $\{E_a\}_{a \in I}$ is disjoint band's family, then

$\{E_a\}_{a \in I}$ is complete family $\iff \forall x \in L$ there exists unique decomposition $x = Sx_a, x_a \in E_a (\forall a \in I)$.

Proposition 1.8 Let $\{L_\beta\}_{\beta \in I}$ be a family of complete soft algebra, let $L = \prod_{\beta \in I} L_\beta$ be their cartesian product with canonical order, then $M_\beta = \{ \prod_{\alpha \in I} x_\alpha \mid x_\alpha = 0, \alpha \neq \beta, x_\beta \in L_\beta \}$ constitute a complete family of the bands of L .

Proposition 1.9 Let L be a complete soft algebra, let $\{E_a\}_{a \in I}$ be a complete family of the disjoint bands, then $L \cong \prod_{a \in I} E_a$ (where by " $\cong$ " denoting isomorphic relations).

Definition 1.10 Let L be a complete soft algebra, let $E \subset L$ be a band in L . E is called a normal band iff $\sup E \wedge (\sup E)' = 0$ (i.e. $1_E \wedge 1'_{E'} = 0$ denoting $\sup E$).

Proposition 1.11 Let L be a complete soft algebra, let $E \subset L$ be a normal band in L . Then $Px = a \Rightarrow Pa' = Px'$; $Px = Py \Rightarrow Px' = Py'$.

Definition 1.12 Let L be a complete soft algebra, let $E \subset L$ be a normal band in L . For any $x \in E$ the element $y = Px' \in E$ is called a derived complementation of x in E (denoting by x'_E). It is evident that $\forall x \in L$, $Px' = (Px)'_L$.

Proposition 1.13 If L is a complete soft algebra, and $E \subset L$ is a normal band, then $\forall x, y \in E$, $x \leq y \Rightarrow x'_E \geq y'_E$, $x'_E = x$.

2. Component in the Soft Algebra

Definition 2.1 Let L be a complete soft algebra. Then $E \subset L$ is called a component in L iff $E^{aa} = E$.

Proposition 2.2 $E \subset L$ is a component in $L \iff \exists D \subset L$, s.t. $D^d = E$.

Definition 2.3 If $D, E \subset L$ are two bands in L , and $D^{dd} = E^{dd}$, then E and D are called co-component bands.

Proposition 2.4 $E \subset L$ is component in $L \iff E$ is maximal of all co-component bands in L .

Proposition 2.5 Let E be component in the soft algebra, we have $(E \vee E^d)^{dd} = L$, where $E \vee E^d$ is minimal ideal including E and E^d .

Proposition 2.6 $A, B \in L(A \cup B)^{dd} \supset A^{dd} \cup B^{dd}$.

Definition 2.7 Let L be a soft algebra, let $D \supset A$ be two ideals in L . D is called a base of A iff $\forall y: 0 \neq y \in D$, $\exists x: 0 \neq x \in A$, s.t. $x \leq y$.

Proposition 2.8 If L is a complete soft algebra every component is an ideal, when L is complete distributive, then every component is a band.

Proposition 2.9 If L is a soft algebra, $A \subset L$ is an ideal in L , then D is a component generated by $A \iff D$ is maximal ideal of all ideals with the base A .

Proposition 2.10 If L is a soft algebra, and $E_1, E_2 \subset L$ are two subsets of L , then $E_1 \perp E_2 \Rightarrow E_1^{dd} \perp E_2^{dd}$.

Proposition 2.11 In the soft algebra the intersection of arbitrary family of the component is again component of L .

Given the non-empty subset D of L , the intersection of all component including D is called the component generated by D . It follows immediately that the minimal component including D is E^{dd} .

3. Maximal and Fundamental Components

Definition 3.1 Let L be a soft algebra, let $E \subset L$ be a component of L . E is called maximal component iff for any component $D \subset L$ such that $D \supset E$, we have $D = E$.

In L a component $F \subset L$ is called a fundamental component if and only if for

any component $D \subset F$, we have $D = 0$.

Proposition 3.2 Let L be a soft algebra, then $E \subset L$ is a maximal component $\iff \exists$ a fundamental component D , such that $E = D^d$.

Proposition 3.3 Let L be a soft algebra. Let $E \subset L$ be a fundamental component of L , then $\forall x, y \in E$, $\{x\}^{dd} = \{y\}^{dd} = E$.

4. Normal Component

Definition 4.1 If L is a soft algebra, $x \in L$ is called a crisp point iff $x \vee x' = 1$.

Naturally the above condition is equivalent to that $x \wedge x' = 0$. A soft algebra is called normal iff for any component E of L , $1_E \triangleq \sup\{x; x \in E\}$ satisfies above condition (i.e. $1_E \vee 1_{E'} = 1$, $1_E \wedge 1_{E'} = 0$).

Proposition 4.2 Let L be a soft algebra. Then the family of all crisp points constructs a Boolean algebra.

Theorem 4.3 Let L be a normal soft algebra. Then L is a Boolean algebra iff for any ideal E of L always have $E^b = E^{dd}$.

Theorem 4.4 The maximal elements of all component of a normal soft algebra constitute a Boolean algebra.

Proposition 4.5 Let L be a soft algebra, and let $A = \{x | x \leq a\}$. (where a is a crisp point and satisfies condition $x \perp a' \Rightarrow x \leq a$), then A is a component of L .

Proposition 4.6 If L is a normal soft algebra, and $E \subset L$ is a component of L , then $E' = E^d$ (where $E' = \{x' \in L | x \in E\}$).

Theorem 4.7 If L is a normal soft algebra, and $E \subset L$ is any subset of L . Then E^{dd} and E^d construct a complete family of components.

Proposition 4.8 Let L be a normal soft algebra, let $x \in L$ be any element. If a component D contains x and $\{x\}^d$, then $D = L$.

Theorem 4.9 If L is a normal soft algebra with a complete family of fundamental components, then L is isomorphic to an L -Fuzzy space.

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模糊情报检索智能系统研究的若干进展*

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本文从情报检索系统的整体性考虑,运用模糊(Fuzzy)理论方法、人工智能和脑理论,研究和解决情报检索中的模糊性(不精确性)问题,为建立一个全新的模糊情报检索智能系统打下应用基础理论的基础。几年来,我们在情报检索系统与模糊集理论,脑理论与人工智能、模糊推理、模糊信息处理等方面做了应用基础理论的研究,出版著作4本,发表论文40多篇。同时,在计算机上进行了情报检索试验性研究,建立了数据库,管理系统。初步设计了自动推理软件工具系统和参考咨询专家系统模型。简要分述如下:

一、情报检索系统与模糊集理论

对已建立的检索系统进行了对比研究,主要结合数学,对情报检索系统进行了全面系统深入的研究,编著了《数学文献检索与利用》一书,是国内数学情报界的第一本教材和专著。译出了《新一代情报检索系统》一书。同时,主持编辑出版了《全国数学外文期刊联合目录》(并建库),为数学科研提供了重要工具。首次在国内外提出了《数学情报学》新分支学科的概念。在整个研究过程中遇到了大量的模糊现象,如边缘学科,交叉学科文献的标引(分类编目),检索语言不能满足用户准确地表达其需求。还有知识获取、检索策略、参考咨询专家系统、模糊信息处理等问题。显然,用原有布尔(Boolean)检索法是不能解决的,因布尔检索的理论基础是布尔代数,二值逻辑。所以只能用模糊集理论,模糊逻辑来解决。针对这些问题,对模糊集理论进行全面系统深入细致的研究,编著了《模糊数学导论》一书,在王国俊教授分子格理论基础,建立了新的“分支理论”,提出了模糊格新模型,揭示了分子内部情况,证明了一系列的理论性质,使认识深化了一步,为解决这些问题作了充分的理论准备,为建立各种数学模型打下了基础,实践证明,采用脑理论,人工智能方法来实现各种数学模型是完全可能的。

二、脑理论与人工智能

从认识科学观点出发,对大脑记忆的组织原则,记忆与推理合一的结构特点,记忆中信息需发展多级Schema语言族表示和平行分布加工特点,以及联想回忆诸方面进行研究,来探索模糊情报检索智能系统知识库中知识的组织、存贮、推理与检索的实现方法。

三、模糊推理

模糊情报检索智能系统应该具有能够模拟领域专家进行情报咨询和问题求解的思维过程能力。从以下几方面进行了研究并在计算机上进行了初步的模拟实践。

1. 应用人工智能的方法和技术,分析研究了计算机模拟人类思维过程的四种不同的推理类型。即完全非聚焦推理、相对非聚焦推理,相对聚焦推理和完全聚焦推理。提出了相对

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非聚焦推理适合开发模糊情报检索智能系统的观点,实践证明了这一推理机制是可行的。

2. 为了完善相对非聚焦推理的推理机制,进而在知识表示,推理算法,控制策略和知识的处理技术等方面进行系统地研究。知识表示采用一般子句语句,并扩充了子句语句中用字符、数字的描述能力。推理算法具有一般性,并对用户透明,这样有利于咨询过程和用户的交互,加速了问题求解的进程。在控制策略方面,提出了模式加权法,并成功地应用了归约技术,解决了命题可信度的传播计算能在推理过程中自动完成的难题。

3. 情报检索系统是一个大容量的信息处理系统,为确保其相容性,对各种非单调逻辑的形式系统进行了全面的分析比较,确定将谓词完备化方法用于情报检索系统是比较可行的,并初步建立了一个实验性系统。

四、模糊信息处理

以现代信息理论为依据,考察智能信息系统的功能及结构特点,分析解决其中带共性的基础理论问题,取得了若干结果。

1. 关于系统信息测度的数学模型。首先提出并系统研究了 *Fuzzy-Random Entropy*, 为应用研究奠定了理论基础,就 *Weighted Entropy* 加权因子的选择作了深入的分析探讨,使之满足处理“意义信息”的要求,为加权熵在软科学中的应用铺平了道路。

2. 关于智能系统图象辨识的性能极限是设计具有视觉功能情报系统所需的重要参数。研究的创新点是通过计算Fuzzy信息含量,分别就视觉系统从单色图象中、彩色图象中提取模糊信息特性取得了定量的研究结果。

3. 关于智能情报检索系统性能描述及其评价,提出了诸如“理解”度、“满意”度、“符合”度等软指标,论证了用加权熵进行定量计算的合理性,在此基础上首次阐明了智能系统整体优化的概念。结合 *Fractal* 和 *AI* 的发展讨论了以分形描述符作为研究智能情报信息系统的工具,首次提出了智能情报网络的概念。

本文是《模糊(Fuzzy)情报检索智能系统应用基础理论研究》的子课题,它是国内外首次提出的研究方向,国外,在理论上的研究,还是几年前罗马尼亚尼哥依塔(Negoita)所做水平。目前,大多数国家都在研究将智能机应用于情报检索,如美国麻省大学,但未用模糊理论,以致许多具有模糊性问题得不到合理解决。日本新成立了国际模糊工程研究所,仅在研究计划中有一项根据模糊信息进行情报检索的研究。国内,有的用模糊方法进行情报资料分类,有的在情报检索中做了某些方面的工作,还有的正在进行智能情报检索系统的研究,这些都只是某一方面的工作,而本项目是从情报检索系统的整体性考虑,对传统的情报检索系统在理论上有所突破,对运用的理论方法,工具和手段有所发展,同时,运用理论成果构造了一些新模型。

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