Mathematical Statistician and Engineering Applications
ISSN: 2094-0343
2326-9865

Secondary k-Kernel Symmetric Intuitionistic Fuzzy Matrices

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Article Info
Page Number: 3622 - 3633
Publication Issue:
Vol 71 No. 4 (2022)

Article History
Article Received: *25 March 2022*
Revised: *30 April 2022*
Accepted: *15 June 2022*
Publication: *19 August 2022*

Abstract

The secondary k- kernel symmetric Intuitionistic fuzzy matrices are described in this studyas well as examples.Discussion is held regarding the relationships among s- k- kernel symmetric Intuitionistic fuzzy matrix, s- kernel symmetric Intuitionistic fuzzy matrix, k- kernel symmetric intuitionistic fuzzy matrix and kernel symmetric intuitionistic fuzzy matrix.For a matrix to be an Intuitionistic fuzzy matrix with an s-k kernel symmetric, necessary and sufficient conditions are established.

Keywords:Intuitionisticfuzzymatrix,kernelsymmetric Intuitionisticfuzzymatrix,s-k-kernelsymmetric Intuitionistic fuzzymatrix.

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1. Introduction

We deal withIntuitionistic fuzzy matrices, concluded a fuzzy algebra F with finding [0, 1] under maximum and minimum operations, are the only matrix taken into consideration in this study. If $R(A) = R(A^T)$, then a Intuitionistic fuzzy matrix A is range symmetric Intuitionistic fuzzy matric, and if $N(A)=N(A^T)$, then it is kernel symmetric Intuitionistic fuzzy matrix.It is commonly known that the concepts of range and kernel symmetry apply to complex matrices. For an Intuitionistic fuzzy matrix, this fails.This inspired us to research s-k kernel symmetric Intuitionistic fuzzy matrices. The study of secondary symmetric Intuitionistic fuzzy matrices whose elements are symmetric about the secondary diagonal, was started by Lee [1].Communication theory applications of persymmetric fuzzy matrices, or matrices that are symmetric about both the diagonals, have been examined by

Cantoni and Paul [2]. As a generalization of s-real and s- hermitian matrices, Hill and Waters [3] created a theory of k-real and k-hermitian matrices.Meenakshi and Jayashree [5] build k- kernel symmetric fuzzy matrices in a manner similar to how k-real and k-hermitian of a complex matrix [3] are developed.

As a generalization of secondary hermitian and hermitian matrices, Meenakshi and Krishnamoorthy[6] introduced the idea of s-k hermitian matrices.In this study, as a special instance of the findings on complex matrices discovered in [7][8].we extend [9] the notion of s-k kernel symmetric intuitionistic fuzzy matrix and Equivalent conditions for various g-inverses of secondary k-kernel Intuitionistic fuzzy matricesto be secondary K-Kernel symmetric are determined.

2. Preliminaries

Let K be the related permutation matrix, and let 'k' be a fixed product of disjoint transpositions in $S_n = \{1, 2, ...n\}$. Throughout, let v be the permutation intuitionistic fuzzy matrix with units in its secondary diagonal.

Let the function is defined $\kappa(x)=(x_{k[1]}, x_{k[2]}, x_{k[3]}, \dots, x_{k[n]} \in F_{n\times 1}$ for $x = x_1, x_2, .., x_n \in F_{[1\times n]}$, where K is involuntary, the following are satisfied the associated permutation matrix where K is a permutation matrix.

(P.2.1) $KK^T = K^TK = I_n, K = K^T, K^2 = I$ and $\Re(x) = Kx$

By the definition of V,

(P.2.2) $V = V^T, VV^T = V^TV = I_n$ and $V^2 = I$

(P.2.3) $N(A) = N(AV), N(A) = N(AK)$

(P.2.4) $(AV)^T = VA^T, (VA)^T = A^TV$

If A^+ exists,then

(P.2.5) $(AV)^+ = VA^+, (VA)^+ = A^+V$

Definition2.1. Intuitionistic fuzzymatrix AiskernelsymmetricIntuitionistic fuzzymatrixiff $N(A) = N(A^T)$.

Lemma2.1. For Intuitionistic fuzzymatrix A belongs to $F_n$andapermutationIntuitionistic fuzzymatrix$P$, null space of A equal to null space of B iff $N(PAP^T) = N(PBP^T)$.

Lemma2.2. Intuitionistic fuzzymatrix$A = KA^T K \Leftrightarrow KA = (KA)(KA)^T(KA)$, Intuitionistic fuzzymatrix$\Leftrightarrow AK = (AK)(AK)^T(AK)$Intuitionistic fuzzymatrix.

3. Secondaryk-kernelsymmetricIntuitionistic fuzzy matrices

Definition3.1. ForIntuitionistic fuzzymatrixA belongs to $F_n$iss -symmetric Intuitionistic fuzzymatrixiff$A=VA^TV$

Definition3.2. ForIntuitionistic fuzzymatrixA belongs to $F_n$iss-kernelsymmetricIntuitionistic fuzzymatrix if$N(A)=N(VA^TV)$.

Definition3.3. ForIntuitionistic fuzzymatrixA belongs to $F_n$iss-k-kernelsymmetric Intuitionistic fuzzymatrixif$N(A)=N(KVA^TVK)$.

Lemma3.1.AIntuitionistic fuzzymatrixA belongs to $F_n$iss-kernelsymmetric Intuitionistic fuzzymatrix⇔ AV iskernelsymmetric Intuitionistic fuzzymatrix⇔ $VA$is kernel symmetric Intuitionistic fuzzymatrix.

Proof.

A iss-kernelsymmetric Intuitionistic fuzzymatrix $\Leftrightarrow N(A)=N(VA^TV)$ [ByDefinition3.2][ByP.$_{2.2}$]

$\Leftrightarrow N(AV)=N((AV)^T)$

$\Leftrightarrow N(VAVV^T)=N(VVA^TV)$

$\Leftrightarrow N(VA)=N((VA)^T)$

$\Leftrightarrow VA$iskernelsymmetric.

Remark 3.1. To be more specific ,when κ(i) = i for i = 1, 2, …, n then the corresponding Intuitionistic fuzzy permutation matrix K reduces to the identity Intuitionistic fuzzy matrix and Definition (3.3) reduces to N (A) = N (VA^{T}V) implying that the matrix is s-kernel symmetric.

Remark3.2. The equivalent permutation intuitionistic fuzzy matrix K simplifies to V for k(i)=n-i+1. N(A) = N(A^T) in definition (3.3) implies that A is a kernel symmetric intuitionistic fuzzy matrix.

Remark3.3. We observe that s-k-symmetric Intuitionistic fuzzy matrix is s-k-kernel symmetric Intuitionistic fuzzy matrix because if A is s-k-symmetric then A =KVATVK, which means that A is s-k-kernel symmetric Intuitionistic fuzzy matrix, then N (A)= N (KVA^T VK).

The reverse, however, is not always true. This V isdemonstrated in the example that follows.

Example3.1. Fork=(1,2), $A=\begin{bmatrix} <1,0> & <0.2,0.3> \\ <0.2,0.3> & <0.4,0.3> \end{bmatrix}$,

$$KVA^TVK = \begin{bmatrix} <1,0> & <0,0> \\ <0,0> & <1,0> \end{bmatrix} \begin{bmatrix} <0,0> & <1,0> \\ <1,0> & <0,0> \end{bmatrix} \begin{bmatrix} <1,0> & <0.2,0.3> \\ <0.2,0.3> & <0.4,0.3> \end{bmatrix} \begin{bmatrix} <0,0> & <1,0> \\ <1,0> & <0,0> \end{bmatrix} \begin{bmatrix} <1,0> & <0,0> \\ <0,0> & <1,0> \end{bmatrix},$$

$$KVA^TVK = \begin{bmatrix} <0.4,0> & <0.2,0> \\ <0.2,0> & <1,0.2> \end{bmatrix} \neq A$$

Here$A$=KA^TK

Therefore A issymmetric IFM,κ–symmetric IFM,s-κ-kernelsymmetricIFM butnots-κ –symmetric IFM.

Example3.2 . For k=(1,2)$V = \begin{bmatrix} <0,0> & <1,0> \\ <1,0> & <0,0> \end{bmatrix}, A = \begin{bmatrix} <0.5,0.2> & <0.4,0.2> \\ <0.4,0.2> & <0.5,0.2> \end{bmatrix}$

$$KVA^TVK = \begin{bmatrix} <1,0> & <0,0> \\ <0,0> & <1,0> \end{bmatrix} \begin{bmatrix} <0,0> & <1,0> \\ <1,0> & <0,0> \end{bmatrix} \begin{bmatrix} <0.5,0.2> & <0.4,0.2> \\ <0.4,0.2> & <0.5,0.2> \end{bmatrix} \begin{bmatrix} <0,0> & <1,0> \\ <1,0> & <0,0> \end{bmatrix} \begin{bmatrix} <1,0> & <0,0> \\ <0,0> & <1,0> \end{bmatrix}$$

$$KVA^TVK = \begin{bmatrix} <0.5,0.2> & <0.4,0.2> \\ <0.4,0.2> & <0.5,0.2> \end{bmatrix} = A$$

A issymmetric,s-κ-symmetricandhencethereforess-k-kernelsymmetric.

Example3.3. Fork=(1,2)(3)

$$K = \begin{bmatrix} <0,0> & <1,0> & <0,0> \\ <1,0> & <0,0> & <0,0> \\ <0,0> & <0,0> & <1,0> \end{bmatrix}, V = \begin{bmatrix} <0,0> & <0,0> & <1,0> \\ <0,0> & <1,0> & <0,0> \\ <1,0> & <0,0> & <0,0> \end{bmatrix}$$

$K \neq V, K \neq I \text{ and } KV \neq VK$

$$A = \begin{bmatrix} <0,0> & <0,0> & <1,0> \\ <0.2,0.3> & <1,0> & <0,0> \\ <0.2,0.3> & <0.4,0.5> & <0,0> \end{bmatrix}$$

$$KV = \begin{bmatrix} <0,0> & <1,0> & <0,0> \\ <1,0> & <0,0> & <0,0> \\ <0,0> & <0,0> & <1,0> \end{bmatrix} \begin{bmatrix} <0,0> & <0,0> & <1,0> \\ <0,0> & <1,0> & <0,0> \\ <1,0> & <0,0> & <0,0> \end{bmatrix}$$

$$KV=\begin{bmatrix}<0,0> & <1,0> & <0,0>\\ <0,0> & <0,0> & <1,0>\\ <1,0> & <0,0> & <0,0>\end{bmatrix}$$

$$VK=\begin{bmatrix}<0,0> & <0,0> & <1,0>\\ <0,0> & <1,0> & <0,0>\\ <1,0> & <0,0> & <0,0>\end{bmatrix}\begin{bmatrix}<0,0> & <1,0> & <0,0>\\ <1,0> & <0,0> & <0,0>\\ <0,0> & <0,0> & <1,0>\end{bmatrix}$$

$$VK=\begin{bmatrix}<0,0> & <0,0> & <1,0>\\ <1,0> & <0,0> & <0,0>\\ <0,0> & <1,0> & <0,0>\end{bmatrix}$$

$$KVA^TVK=\begin{bmatrix}<0,0> & <1,0> & <0,0>\\ <0,0> & <0,0> & <1,0>\\ <1,0> & <0,0> & <0,0>\end{bmatrix}\begin{bmatrix}<0,0> & <0.2,0.3> & <0.2,0.3>\\ <0,0> & <1,0> & <0.4,0.5>\\ <1,0> & <0,0> & <0,0>\end{bmatrix}\begin{bmatrix}<0,0> & <0,0> & <1,0>\\ <1,0> & <0,0> & <0,0>\\ <0,0> & <1,0> & <0,0>\end{bmatrix}$$

$$KVA^TVK=\begin{bmatrix}<1,0> & <0.4,0> & <0,0>\\ <0,0> & <0,0> & <1,0>\\ <0.2,0> & <1,0> & <0,0>\end{bmatrix}\neq A$$

$$A\neq KVA^TVK$$

Hence A isnots-k-symmetric.But s-k- kernel symmetric.

i.e) $N(A)=N(KVA^TVK)=<0,0>$

Theorem3.1. For Intuitionistic fuzzymatrix A belongs to $F_n$thefollowingareequivalent

(1)N(A) =N(KVA^{T}VK)

(2)N(KVA)=N((KVA)^T)

(3)N(AKV)=N((AKV)^T)

(4) N(AVK) =N((AVK)^T)

(5) N(VKA) =N((VKA)^T)

(6)N(VA)=N(K(VA)^{T}K)

(7) N(AV) =N(K(AV)^{T}K)

(8)N(AK)=N(V(AK)^{T}V)

(9) N(KA) =N(V(KA)^{T}V)

(10)N(A^T)=N(KVA)

(11) N(A)=N(KVA^T)

Proof:

$N(A) = N(KVA^T VK)$

$\Leftrightarrow N(A) = N(KVA^T)$ (Definition 3.2)

$\Leftrightarrow N(AVK) = N((AVK)^T)$ (by $P_{2.3}$)

$\Leftrightarrow$AVK is kernel symmetric

$\Leftrightarrow (VK)(AVK)(VK)^T$(kernel symmetric Lemma 2.1)

$\Leftrightarrow$ VKA is kernelsymmetric

$\Leftrightarrow$ KA (s- kernel symmetric)

Therefore , (1)iff (4)iff (5) iff(9) holds

(2)iff(6)

$\Leftrightarrow N(KVA) = N((KVA)^T)$

$\Leftrightarrow N(K^T KVA) = N((K^T KVA)^T)$

$\Leftrightarrow N(VA) = N(VA)^T)$

$\Leftrightarrow N(VA) = N(K(VA)^T K)$

Therefore , VA is K kernel symmetric

(2)iff(6) holds

(2) iff (10)

$\Leftrightarrow N(KVA) = N((KVA)^T)$

$\Leftrightarrow N(KVA) = N(A^T)$ (By P. $_{2.3}$)

Thus(2)iff(10)hold.

(4)iff(11)

$\Leftrightarrow N(AVK) = N((AVK)^T)$

$\Leftrightarrow N(A) = N(KVA^T)$ (By P. $_{2.3}$)

(4)iff(11) hold

(1) iff (4) iff (7)

$\Leftrightarrow N(A) = N(KVA^T VK)$

$\Leftrightarrow N(A) = N((AVK)^T)$

$\Leftrightarrow N(AVK) = N((AVK)^T)$ (AVK is kernel symmetric)

$\Leftrightarrow N(AVKK^T) = N((AVKK^T)^T)$

$\Leftrightarrow N(AV) = N((AV)^T)$

$\Leftrightarrow N(AV) = N(K(AV)^T K)$ (AV is k- kernel symmetric)

(1) iff (4) iff (7) hold

(3)iff(8)

$\Leftrightarrow N(AKV)=N((AKV)^T)$

$\Leftrightarrow N(AK)=N(V(AK)^TV)$

(3) iff(8) holds

HencetheTheorem

Corollary3.1. For Intuitionistic fuzzymatrix A belongs to $F_n$thefollowingareequivalent

(1)$N(A)=N(VA^TV)$

(2)$N(VA)=N((VA)^T)$

(3)$N(AV)=N((AV)^T$

(4) $N(A^T)=N(VA)$

(5) $N(A)=N(VA^T)$

Proof: (1) implies (2)

$\Leftrightarrow N(A)=N(VA^TV)$

$\Leftrightarrow N(VA)=N(VVA^TV)$

$\Leftrightarrow N(VA)=N(V^2A^TV)$

$\Leftrightarrow N(VA)=N((VA)^T)$

(1) implies (2)hold

(1) implies (3)

$\Leftrightarrow N(A)=N(VA^TV)$

$\Leftrightarrow N(AV)=N(VA^TVV)$

$\Leftrightarrow N(AV)=N(VA^TV^2)$

$\Leftrightarrow N(AV)=N(AV)^T$

(1) implies (3) holds

(1) implies (4)

$N(A^T)=N((VA^TV)^T)$

$N(A^T)=N((VA^TV)^T)$

$N(A^T)= N(VA)$

(1) implies (4) holds

(1) implies (5) easily verified

(5) implies (1) easily

verified

HencetheTheorem

Lemma3.2. For Intuitionistic fuzzymatrix A belongs to F_n,if

$$(VKA)^{+}\text{exists}\Leftrightarrow(KA)^{+}\text{exists}\Leftrightarrow A^{+}\text{exists}.$$

Proof:$(VKA)^{+}$existsiff $(VKA)^T \in (VKA)\{1\}$

$$iff\ \ VKA = VKA(VKA)^T VKA$$

$$iff\ \ VKA = VKA(KA)^T VV(KA)$$

$$iff\ \ KA = KA(KA)^T(KA)$$

$$iff\ \ (KA)^{+}\ exists\ iff\ \ A^{+}\ exists$$ [Lemma3.4in[8]]

Lemma3.3 ForIntuitionistic fuzzymatrix A belongs to F_n if $(KVA)^{+}$exists$\Leftrightarrow$ A^{+}exists.

Proof:$(A)^{+}$existsiff $(VA)^{+}$ exist

iff $VA= (VA)(VA)^{+}(VA)$

$KVA= K(VA)(VA)^{+}(VA)$

$KVA= K(VA)(VA)^{+}KK(VA)$

$KVA= (KVA)(KVA)^{+}(KVA)$

$(KVA)^T \in (KVA)\{1\}$

Therefore , $(KVA)^{+}$ exist.

Theorem3.2. For Intuitionistic fuzzymatrix A belongs to F_n

.Thenanytwoofthefollowingconditionsimply theotherone.

(1) $N(A)=N(KA^TK)$

(2) $N(A)=N(KVA^TVK)$.

(3) $N(A^T)=N((KAV)^T)$

Proof: A

(1)&(2)$\Rightarrow$(3)

ByTheorem3.1

$N(A)=N(KVA^TVK)$ implies $N(A)=N((AVK)^T)$

$N(KAK)=N(VA^TK)$ (Lemma 2.1)

$N(A)=N(KA^TK)$

$N(KAK)=N(A^T)$ (Lemma 2.1)

$N(A^T)= N((KAV)^T)$

Therefore, (3) hold

(1) & (3) ⇒ (2)

$N(A)=N(KA^TK)$ implies $N(KAK)= N(A^T)$

Hence (1) and (3) $N(KAK)= N((KAV)^T)$

$N(A)=N(KVA^T)$ (Lemma 2.1)

A is s-k kernel symmetric [Theorem 3.1]

Therefore (2) holds.

(2) & (3) ⇒ (1)

A is s-k kernel symmetric

$N(A)=N(KVA^T)$

$N(KAK)= N((VA^TK)^T)$

Hence (2) and (3)

$N(KAK)= N(A^T)$

$N(A)= N(KA^TK)$

therefore (1) hold.

Hence the theorem.

4. s- k-Kernel Symmetric IFM Regular IFM

This section has established the existence of several generalized inverses of IFM in F_n. It is determined additional comparable conditions for different g-inverses of an s-k-kernel symmetric IFM to be s-k kernel symmetric IFM. Generalized inverses belonging to the sets A {1, 2}, A {1, 2, 3} and A {1, 2, 4} of s-k-kernel symmetric IFM A are characterized.

Definition:4.1 The IFM $A\in F_{m\times n}$is said to be regular (or g-inverse) if there exists another IFM, $X\in F_{n\times m}$such that AXA = A. The generalized inverse of an IFM is not unique that is an IFM has many generalized inverses exists .

Definition:4.2 For IFM $A\in F_{m\times n}$ and another IFM, $X\in F_{n\times m}$ satisfies the given equation AXA= A and $(AX)^T =AX$, then X is called least square generalized inverse of A which is called it as A{1,3} inverses.

Definition:4.3 For IFM A and another IFM, $X\in F_{n\times m}$ satisfies the given equation AXA= A and $(XA)^T =XA$, then X is called minimum norm generalized inverse of A which is called it as A{1,4} inverses.

Definition:4.4 For IFM (XA) $\in F_{m\times n}$ and another IFM, $(XA)^T \in F_{n\times m}$ is said to be Moore Penrose inverse of XA if $XA(XA)^T XA = XA$, $(XA)^T XA(XA)^T = (XA)^T$,
$[XA(XA)^T]^T = XA(XA)^T$ and $[(XA)^T XA]^T = (XA)^T XA$.

The Moore Penrose inverse of XA is denoted by $(XA)^+$

Theorem 4.1: Let A belongs to F_n, X belongs to A {1,2} and AX, XA, are s- κ-Kernelsymmetric IFM. Then A is s- κ -kernel symmetric IFM⇔ X is s- κ –kernel symmetric IFM.

Proof: $N(KVA) = N(KVAXA) \subseteq N(XA)$ [since A = AXA]

$= N(XVVA) = N(XVKKVA) \subseteq N(KVA)$

Hence, $N(KVA) = N(XA)$

$= N(KV(XA)^T VK)$[XA is s- κ-kernel symmetric IFM]

$= N(A^T X^T VK)$

$= N(X^T VK)$

$= N((KVX)^T)$

$N((KVA)^T) = N(A^T VK)$

$= N(X^T A^T VK)$

$= N((KVAX)^T)$

$= N(KVAX)$ [is s- κ - kernel symmetric]

$= N(KVX)$

KVX is kernel symmetric $\Leftrightarrow N(KVA) = N((KVA)^T)$

$\Leftrightarrow N((KVX)^T) = N(KVX)$

⇔ KVX is kernel symmetric

⇔ X is s- κ-kernel symmetric.

Theorem 4.2: Let A belongs to F_n, X ∈ A {1,2,3}, $N(KVA) = N((KVX)^T)$.Then A is s-κ-Kernel symmetric IFM⇔ X is s- κ -kernel symmetric IFM.

Proof: Since X belongs to A {1,2,3} we have AXA =A,XAX =X, $(AX)^T = AX$

$N((KVA)^T) = N(X^T A^T VK)$ [By using A = AXA]

$= N(KV(AX)^T)$

$= N((AX)^T)$ [By $P._{2.3}$]

$= N(AX)$ $[(AX)^T = AX]$

$= N(X)$ [By using X = XAX]

$= N(KVX)$ [By $P_{2.3}$]

KVA is kernel symmetric IFM$\Leftrightarrow$N(KVA) = N $((KVA)^T)$

$\Leftrightarrow$N$((KVX)^T)$ = N(KVX)

$\Leftrightarrow$ KVX is kernel symmetric

$\Leftrightarrow$ X is s- κ -kernel symmetric.

Theorem 4.3: Let A belongs to F_n, A {1,2,4} N$((KVA)^T)$ = N(KVX) . Then A is s- κ-Kernel symmetric IFM$\Leftrightarrow$ X is s- κ-kernel symmetric IFM.

Proof: Since X $\in$ A {1, 2, 4}, we have AXA = A, XAX = X, $(XA)^T$= XA

N(KVA) = N(A) [By P. 2.3]

= N(XA) [XAX = A, AXA = A] = N$((XA)^T)$ [$(XA)^T$ = XA]

= N(A^TX^T)

= N (X^T)

= N$((KVX)^T)$. [P.2.3]

KVA is kernel symmetric IFM$\Leftrightarrow$N(KVA) = N $((KVA)^T$

$\Leftrightarrow$N$((KVX)^T)$ = N(KVX)

$\Leftrightarrow$ KVX is kernel symmetric IFM

$\Leftrightarrow$ X is s- κ –kernel symmetric IFM.

In particular for K = I , the above Theorems reduces to equivalent conditions for various g-inverses of a s-kernel symmetric IFM to be secondary kernel symmetric IFM.

Corollary 4.1: Let A belongs to F_n, X belongs A {1, 2} and AX, XA are s-kernel symmetric IFM. Then A is s- kernel symmetric IFM$\Leftrightarrow$ X is s- kernel symmetric IFM.

Corollary 4.2: Let A belongs to F_n, X belongs toA {1, 2, 3}, N(KVA) = N$((VX)^T)$. Then A is s-kernel symmetric IFM$\Leftrightarrow$ X is s- kernel symmetric IFM.

Corollary 4.3: Let A belongs to F_n,X belongs toA {1, 2, 4} ,N$((VA)^T)$ = N(VX) . Then A is s-kernel symmetric IFM$\Leftrightarrow$ X is s- kernel symmetric IFM.

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