A Study on Interval-Valued Intuitionistic Fuzzy Cognitive Map in Prioritizing Various Technologies Used in Military Sectors.

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Abstract:- The purpose of this research is to prioritize the best technology used in Military Sectors, which is considered as the Multi Attribute Decision Making (MADM) problem. In this study, an integrated algorithmic approach for Multi Attribute Decision Making is utilized by combining the likelihood Function and Interval Valued Intuitionistic Fuzzy Cognitive Map (IVIFCM). The final Decision matrix is obtained by utilizing the IVIF decision matrix and FCM matrix which are gathered from the expert by linguistic variables & utilizing Lingo Software for the alternatives. The chosen problem demonstrates twelve alternatives and eight attributes to evaluate the utility of the proposed integrated algorithm.

Keywords: Likelihood function, Interval Valued Intuitionistic Fuzzy Cognitive Map, Multi-Attribute Decision Making, Technologies used in Military.

1. Introduction

Making decision today, demonstrates how essential it is to the entire way of life. A major component of decision making plays out by Multi Attribute Decision Making (MADM). In MADM problem, alternatives are scrutinized in terms of the attributes to provide feasible solution to solve the problem. The primary process of decision making is to gather information from the domain expert, for ranking the alternatives to get feasible solution for the problem [6]. In the modern world, Technology has become essential in all industries. It simplifies human work and assists in acquiring broad knowledge in diverse fields. This research, particularly focusing on Military field. The role of Human is very essential in Military. But there are so many risk factors for humans, which includes unexpected attacks from enemies, carrying of heavy weapons in battle field, Loss of lives in war, etc. Even though humans play vital role in army, but still there are some information lags in getting instructions, plans and communication. To overcome these risk factors, advanced technologies can be used in Military field. Prioritizing various technologies used in Military Sector is considered as the Multi Attribute Decision Making problem.

This research work includes the combination of Likelihood function and Interval Valued Intuitionistic Fuzzy Cognitive Map. Obtain the final decision matrix by utilizing the IVIF Decision matrix and FCM matrix which are gathered from the expert. The aspect of likelihood concept is to extract the auxiliary LP model from the decision matrix, resolving it to obtain relative closeness coefficient intervals & utilizing Lingo Software for alternatives, and then finding and sorting the final results according to the likelihood matrix's predicted optimal degree membership [6].

2. Objectives

***** To prioritize the best advanced technology used in military sector by the proposed algorithm.

* To implement an integrated algorithm by combining IVIFCM & Likelihood Function.

3. Methods

3.1. Intuitionistic Fuzzy Sets

Let $\breve{Y}$ be an Intuitionistic Fuzzy Set in W and it is represented by

$$\breve{Y} = \{< w, \varphi_{\breve{Y}}(w), \vartheta_{\breve{Y}}(w) >: w \in W\}$$

where, $\varphi_{\breve{Y}} \rightarrow Degree\ of\ membership$, $\vartheta_{\breve{Y}} \rightarrow Degree\ of\ non\ membership$ and it is defined as $\varphi_{\breve{Y}}: W \rightarrow [0,1]$, $\vartheta_{\breve{Y}}: W \rightarrow [0,1]$ & for every $w \in W$: $0 \leq \varphi_{\breve{Y}} + \vartheta_{\breve{Y}} \leq 1$ [1].

3.2 Interval Valued Intuitionistic Fuzzy Sets

Let consider $\breve{Y}$ on W be an IVIFS, represented by

$$\breve{Y} = \{< w, [\varphi^L_{\breve{Y}}(w), \varphi^U_{\breve{Y}}(w)], [\vartheta^L_{\breve{Y}}(w), \vartheta^U_{\breve{Y}}(w)] >: w \in W\}$$

where, $[\varphi^L_{\breve{Y}}(w), \varphi^U_{\breve{Y}}(w)]$ → Interval Membership Function, $[\varphi^L_{\breve{Y}}(w), \varphi^U_{\breve{Y}}(w)]$ → Interval Non Membership Function [2].

3.3 Operations on IVIFS

(i) Addition operator

$$\breve{Y} \oplus \breve{Z} = \{< w, [\varphi^L_{\breve{Y}}(w) + \varphi^L_{\breve{Z}}(w) - \varphi^L_{\breve{Y}}(w).\varphi^L_{\breve{Z}}(w), \varphi^U_{\breve{Y}}(w) + \varphi^U_{\breve{Z}}(w) - \varphi^U_{\breve{Y}}(w).\varphi^U_{\breve{Z}}(w)], [\vartheta^L_{\breve{Y}}(w).\vartheta^L_{\breve{Z}}(w), \vartheta^U_{\breve{Y}}(w).\vartheta^U_{\breve{Z}}(w)] >: w \in W\}$$

(ii) Multiplication operator

$$\breve{Y} \otimes \breve{Z} = \{< w, [\varphi^L_{\breve{Y}}(w).\varphi^L_{\breve{Z}}(w), \varphi^U_{\breve{Y}}(w).\varphi^U_{\breve{Z}}(w)], [\vartheta^L_{\breve{Y}}(w) + \vartheta^L_{\breve{Z}}(w) - \vartheta^L_{\breve{Y}}(w).\vartheta^L_{\breve{Z}}(w), \vartheta^U_{\breve{Y}}(w) + \vartheta^U_{\breve{Z}}(w) - \vartheta^U_{\breve{Y}}(w).\vartheta^U_{\breve{Z}}(w)] >: w \in W\}$$

3.4 Likelihood Function

The Likelihood $g_l > h_l$ is $\Pr(g_l > h_l) = \begin{cases} 1, & g_l < h_l \\ 0, & g_l \geq h_l \end{cases}$, where g_l and h_l are real numbers.

The definition of Likelihood $g_l \geq h_l$ is

$$\Pr(g_l \geq h_l) = max\left\{1 - \max\left(\frac{{h_l}^+ - {g_l}^-}{L(g_l) + L(h_l)}, 0\right), 0\right\}$$

Where $g_l = [g_l^-, {g_l}^+]$,$h_l = [h_l^-, h_l^+]$, $L(g_l) = [g_l^+ - {g_l}^-]$ and $L(h_l) = [h_l^+ - {h_l}^-]$,

g_l & h_l are interval numbers [4].

3.5 IVIFCM algorithm implementing Likelihood Function

An algorithm approach of IVIFCM [3] using Likelihood Method [4] is discussed for MADM.

Step 1: Utilising a Linguistic Variable, get the IVIF Decision matrix from a Domain Expert.

Step 2: Obtaining the FCM matrix from the expert and also its value in terms of Linguistic variable.

Step 3: From step 2 and 3, Determine the final Decision matrix.

Step 4: To find the relative closeness coefficient intervals for the alternatives, determine the auxiliary LP model and evaluate it.

$$O^u_p = \max\{\sum_{q=1}^{h}[s_q\varphi^u_{pq} + v_q(1 - \vartheta^l_{pq})]\}$$

$$\text{s.t}\begin{cases} u\alpha_q^l \leq s_q \leq u\alpha_q^u & (q = 1,2,3, \ldots . . h) \\ u\beta_q^l \leq v_q \leq u\beta_q^u & (q = 1,2,3, \ldots . . h) \\ \sum_{q=1}^{h}(s_q + v_q) = 1 \\ u \geq 0 \end{cases} \quad \ldots\ldots \text{(i)} \quad \&$$

$$O_k^l = \min\{\sum_{q=1}^{h}[s_q\varphi_{pq}^l + v_q(1 - \vartheta_{pq}^u)]\}$$

$$\text{s.t}\begin{cases} u\alpha_q^l \leq s_q \leq u\alpha_q^u & (q = 1,2,3, \ldots . . h) \\ u\beta_q^l \leq v_q \leq u\beta_q^u & (q = 1,2,3, \ldots . . h) \\ \sum_{q=1}^{h}(s_q + v_q) = 1 \\ u \geq 0 \end{cases} \quad \ldots\text{.(ii)}$$

Step 5: Utilising Lingo Software for Alternatives.

Step 6: Using the following formula, find the likelihood of $w_p \geq w_q$ of Alternatives w_p& w_q

$$\Pr(w_p \geq w_q) = \Pr(o_p \geq o_q)$$

$$\Pr(w_p \geq w_q) = max\left\{1 - \max\left(\frac{O_r^u - O_p^l}{L(O_p) + L(O_r)}, 0\right), 0\right\} \quad \ldots\text{.(iii)}$$

Where, $O_p = [\, O_p^l, O_p^u,\ O_r = [\, O_r^l, O_r^u\,]$, $\mathrm{L}(O_p) = O_p^u - O_p^l$, $\mathrm{L}(O_r) = O_r^u - O_r^l$

Step 7: Generate the likelihood matrix, that's a pairwise comparison of the alternative from above step 6

$$P_{lh} = (d_{pr})_{g\times h} = \begin{array}{c} \\ Z_1 \\ Z_2 \\ \vdots \\ Z_g \end{array}\begin{array}{c} \begin{array}{cccc} Z_1 & Z_2 & \cdots & Z_g \end{array} \\ \begin{bmatrix} d_{11} & d_{12} & \cdots & d_{1g} \\ d_{21} & d_{22} & \cdots & d_{2g} \\ \vdots & \vdots & \vdots & \vdots \\ d_{g1} & d_{g2} & \cdots & d_{gg} \end{bmatrix} \end{array}$$

Step 8: Determine the optimal degree θd_p for all the alternative, by using the following equation.

$$\theta d_p = \frac{1}{g(g-1)}\left(\sum_{r=1}^{g} d_{pr} + \frac{g}{2} - 1\right) \quad \ldots\text{.(iv)}$$

Step 9: Assemble the optimal degree in the decreasing sequence to figure out the best alternative.

3.6 Problem Description

Technology is becoming a vital component of every sector. Particularly, in army there are various Military Technologies (MT) , which are highly useful in defending the nation from attackers. Even though humans are essential in Military, there are various risks involved. MT can be utilised to prevent these risk factors. Taking into account, the alternatives areAl_1-Artificial Intelligence, Al_2-Internet of Military Things, Al_3- Robotics Autonomous System, Al_4-5G, Al_5-Advanced Defence Equipment, Al_6-Big Data, Al_7-Cyber Warfare,Al_8-Block Chain, Al_9-Immersive Technology, Al_{10}-Additive Manufacturing, Al_{11}-Hypersonic Missiles, Al_{12}- Digital Health-Care Automation[7][10].

To analyse decisions and to prioritize different MT, some attributes are taken into account. The attributes include, At_1-Surveillance, At_2-Cyber Security, At_3-Reconnaissance, At_4-Data Processing and Analysis, At_5-Target Recognition, At_6-Remote Training, At_7-Monitoring Soldier's Health, At_8-Ease Transport. The significance of Qualities is required in Decision Making process to evaluate the alternatives. The list of attributes relative importance, determined by a Senior Ex. Army person is mentioned below

$At_1 -$ [0.75,0.8][0.15,0.2],
$At_2 -$ [0.5,0.62][0.2,0.35],
$At_3 -$ [0.42,0.57][0.3,0.4],
$At_4 -$ [0.65,0.7][0.25,0.3],
$At_5 -$ [0.34,0.47][0.27,0.32],
$At_6 -$ [0.3,0.42][0.45,0.58],
$At_7 -$ [0.1,0.25][0.75,0.8],
$At_8 -$ [0.27,0.32][0.55,0.65]

Step 1 : Obtained IVIF Decision matrix from a Domain Expert (Senior Ex.Army Person) by utilising a linguistic variable.

	Al_1	Al_2	Al_3	Al_4	Al_5	Al_6	Al_7	Al_8	Al_9	Al_{10}	Al_{11}	Al_{12}
At_1	[0.70,0.80] [0.10,0.20]	[0.50, 0.60] [0.20, 0.30]	[0.70, 0.80] [0.10, 0.20]	[0.30, 0.40] [0.40, 0.50]	[0.50, 0.60] [0.20, 0.30]	[0.50,0.60] [0.20,0.30]	[0.50, 0.60] [0.20, 0.30]	[0.30, 0.40] [0.40, 0.50]	[0.50, 0.60] [0.20, 0.30]	[0.20, 0.30] [0.50, 0.60]	[0.20, 0.30] [0.50, 0.60]	[0.50, 0.60] [0.20, 0.30]
At_2	[0.70,0. [0.10,0.	[0.50, 0.60] [0.20, 0.30]	[0.30, 0.40] [0.40, 0.50]	[0.50, 0.60] [0.20, 0.30]	[0.30, 0.40] [0.40, 0.50]	[0.20,0. [0.50,0.	[0.70, 0.80] [0.10, 0.20]	[0.50, 0.60] [0.20, 0.30]	[0.20, 0.30] [0.50, 0.60]	[0.20, 0.30] [0.50, 0.60]	[0.20, 0.30] [0.50, 0.60]	[0.20, 0.30] [0.50, 0.60]
At_3	[0.50,0.60] [0.20,0.30]	[0.50, 0.60] [0.20, 0.30]	[0.70, 0.80] [0.10, 0.20]	[0.20, 0.30] [0.50, 0.60]	[0.50, 0.60] [0.20, 0.30]	[0.30,0.40] [0.40,0.50]	[0.30, 0.40] [0.40, 0.50]	[0.20, 0.30] [0.50, 0.60]	[0.50, 0.60] [0.20, 0.30]	[0.30, 0.40] [0.40, 0.50]	[0.10, 0.20] [0.70, 0.80]	[0.20, 0.30] [0.50, 0.60]
At_4	[0.70,0.80] [0.10,0.20]	[0.50, 0.60] [0.20, 0.30]	[0.50, 0.60] [0.20, 0.30]	[0.20, 0.30] [0.50, 0.60]	[0.70, 0.80] [0.10, 0.20]	[0.50,0.60] [0.20,0.30]	[0.30, 0.40] [0.40, 0.50]	[0.50, 0.60] [0.20, 0.30]	[0.20, 0.30] [0.50, 0.60]	[0.30, 0.40] [0.40, 0.50]	[0.20, 0.30] [0.50, 0.60]	[0.10, 0.20] [0.70, 0.80]
At_5	[0.30,0.40] [0.40,0.50]	[0.30, 0.40] [0.40, 0.50]	[0.30, 0.40] [0.40, 0.50]	[0.50, 0.60] [0.20, 0.30]	[0.70, 0.80] [0.10, 0.20]	[0.50,0.60] [0.20,0.30]	[0.50, 0.60] [0.20, 0.30]	[0.30, 0.40] [0.40, 0.50]	[0.20, 0.30] [0.50, 0.60]	[0.20, 0.30] [0.50, 0.60]	[0.70, 0.80] [0.10, 0.20]	[0.20, 0.30] [0.50, 0.60]
At_6	[0.50,0.60] [0.20,0.30]	[0.50, 0.60] [0.20, 0.30]	[0.30, 0.40] [0.40, 0.50]	[0.10, 0.20] [0.70, 0.80]	[0.50, 0.60] [0.20, 0.30]	[0.20,0.30] [0.50,0.60]	[0.30, 0.40] [0.40, 0.50]	[0.20, 0.30] [0.50, 0.60]	[0.50, 0.60] [0.20, 0.30]	[0.50, 0.60] [0.20, 0.30]	[0.30, 0.40] [0.40, 0.50]	[0.20, 0.30] [0.50, 0.60]
At_7	[0.50,0.60] [0.20,0.30]	[0.70, 0.80] [0.10, 0.20]	[0.20, 0.30] [0.50, 0.60]	[0.10, 0.20] [0.70, 0.80]	[0.30, 0.40] [0.40, 0.50]	[0.10,0.20] [0.70,0.80]	[0.20, 0.30] [0.50, 0.60]	[0.10, 0.20] [0.70, 0.80]	[0.20, 0.30] [0.50, 0.60]	[0.10, 0.20] [0.70, 0.80]	[0.10, 0.20] [0.70, 0.80]	[0.70, 0.80] [0.10, 0.20]
At_8	[0.70,0.80] [0.10,0.20]	[0.20, 0.30] [0.50, 0.60]	[0.50, 0.60] [0.20, 0.30]	[0.20, 0.30] [0.50, 0.60]	[0.50, 0.60] [0.20, 0.30]	[0.10,0.20] [0.70,0.80]	[0.20, 0.30] [0.50, 0.60]	[0.20, 0.30] [0.50, 0.60]	[0.10, 0.20] [0.70, 0.80]	[0.10, 0.20] [0.70, 0.80]	[0.50, 0.60] [0.20, 0.30]	[0.20, 0.30] [0.50, 0.60]

Table 3.6.1 IVIF Decision Matrix from a Domain Expert.

Step 2 : Obtained FCM matrix , from the Domain Expert(Senior Ex.Army Person) in terms of Linguistic variable

Table 3.6.2 FCM Matrix from the Expert

	At_1	At_2	At_3	At_4	At_5	At_6	At_7	At_8
At_1	-	[0.60, 0.80 [0.10, 0.20	[0.50, 0.60 [0.30, 0.40	[0.30, 0.50 [0.40, 0.50	[0.30, 0.50 [0.40, 0.50	[0.20, 0.30 [0.50, 0.70	[0.20, 0.30 [0.50, 0.70	[0.00, 0.10 [0.70, 0.90
At_2	[0.30, 0.50 [0.40, 0.50	-	[0.30, 0.50 [0.40, 0.50	[0.50, 0.60 [0.30, 0.40	[0.50, 0.60 [0.30, 0.40	[0.60, 0.80 [0.10, 0.20	[0.30, 0.50 [0.40, 0.50	[0.30, 0.50 [0.40, 0.50
At_3	[0.50, 0.60 [0.30, 0.40	[0.30, 0.50 [0.40, 0.50	-	[0.60, 0.80 [0.10, 0.20	[0.50, 0.60 [0.30, 0.40	[0.00, 0.10 [0.70, 0.90	[0.20, 0.30 [0.50, 0.70	[0.60, 0.80 [0.10, 0.20
At_4	[0.20, 0.30 [0.50, 0.70	[0.30, 0.50 [0.40, 0.50	[0.30, 0.50 [0.40, 0.50	-	[0.20, 0.30 [0.50, 0.70	[0.50, 0.60 [0.30, 0.40	[0.30, 0.50 [0.40, 0.50	[0.50, 0.60 [0.30, 0.40
At_5	[0.20, 0.30 [0.50, 0.70	[0.00, 0.10 [0.70, 0.90	[0.60, 0.80 [0.10, 0.20	[0.20, 0.30 [0.50, 0.70	-	[0.30, 0.50 [0.40, 0.50	[0.20, 0.30 [0.50, 0.70	[0.50, 0.60 [0.30, 0.40
At_6	[0.00, 0.10 [0.70, 0.90	[0.20, 0.30 [0.50, 0.70	[0.50, 0.60 [0.30, 0.40	[0.30, 0.50 [0.40, 0.50	[0.00, 0.10 [0.70, 0.90	-	[0.30, 0.50 [0.40, 0.50	[0.30, 0.50 [0.40, 0.50
At_7	[0.30, 0.50 [0.40, 0.50	[0.00, 0.10 [0.70, 0.90	[0.20, 0.30 [0.50, 0.70	[0.00, 0.10 [0.70, 0.90	[0.30, 0.50 [0.40, 0.50	[0.50, 0.60 [0.30, 0.40	-	[0.20, 0.30 [0.50, 0.70
At_8	[0.30, 0.50 [0.40, 0.50	[0.20, 0.30 [0.50, 0.70	[0.30, 0.50 [0.40, 0.50	[0.30, 0.50 [0.40, 0.50	[0.50, 0.60 [0.30, 0.40	[0.00, 0.10 [0.70, 0.90	[0.50, 0.60 [0.30, 0.40	-

Step 3: Final Decision Matrix obtained from step 1 and 2

	Al_1	Al_2	Al_3	Al_4	Al_5	Al_6	Al_7	Al_8	Al_9	Al_{10}	Al_{11}	Al_{12}
At_1	[0.904,0.9 [0.0014,0	[0.8,0.94 [0.005,0.	[0.88,0.97 [0.003,0.0	[0.59,0.8 [0.032,0.	[0.81,0.9 [0.0044,0	[0.7,0.86 [0.018,0.	[0.75,0.91 [0.0088,0	[0.59,0.8 [0.028,0	[0.705,0.8 [0.015,0.0	[0.46,0.7 [0.054,0	[0.512,0 [0.04,0.1	[0.71,0.884] [0.016,0.072]
At_2	[0.91,0.98 [0.0009,0	[0.784,0. [0.004,0.	[0.77,0.94 [0.0052,0	[0.66,0.8 [0.02,0.0	[0.733,0. [0.005,0.	[0.59,0.8 [0.021,0.	[0.844,0.9 [0.004,0.0	[0.7,0.87 [0.014,0	[0.61,0.85 [0.019,0.1	[0.49,0.7 [0.028,0	[0.46,0. [0.04,0.	[0.528,0.797] [0.026,0.129]
At_3	[0.91,0.98 [0.0009,0	[0.87,0.9 [0.0018,0	[0.913,0.9 [0.0097,0	[0.672,0. [0.014,0.	[0.91,0.9 [0.0008,0	[0.75,0.9 [0.008,0.	[0.8,0.95] [0.0044,0	[0.67,0.8 [0.014,0	[0.8,0.93] [0.0066,0	[0.664,0 [0.02,0.6	[0.69,0.91] [0.007,0.05]	[0.65,0.86] [0.0175,0.066]
At_4	[0.932,0.9 [0.0006,0	[0.83,0.9 [0.0022,0	[0.86,0.97 [0.002,0.1	[0.61,0.8 [0.0245,0	[0.91,0.9 [0.001,0.	[0.745,0. [0.0098,0	[0.76,0.92 [0.0084,0	[0.76,0.9 [0.01,0.0	[0.664,0.8 [0.013,0.0	[0.62,0.8 [0.024,0	[0.58,0.825] [0.027,0.174]	[0.49,0.79] [0.0315,0.12]
At_5	[0.874,0.9 [0.002,0.0	[0.78,0.9 [0.0056,0	[0.811,0.9 [0.006,0.0	[0.745,0. [0.014,0.	[0.91,0.9 [0.002,0.	[0.73,0.8 [0.013,0.	[0.82,0.94 [0.0058,0	[0.664,0 [0.02,0.0	[0.61,0.84 [0.023,0.0	[0.5,0.75 [0.045,0	[0.832,0.94] [0.008,0.046]	[0.62,0.85] [0.023,0.092]
At_6	[0.89,0.98 [0.001,0.0	[0.86,0.9 [0.0022,0	[0.7,0.89] [0.009,0.0	[0.57,0.8 [0.027,0.	[0.84,0.9 [0.004,0.	[0.62,0.8 [0.22,0.0	[0.77,0.93 [0.0064,0	[0.66,0.8 [0.016,0	[0.699,0.8 [0.014,0.0	[0.68,0.8 [0.02,0.0	[0.60,0.76] [0.02,0.08]	[0.632,0.84] [0.024,0.096]

At_7	[0.88,0.97 [0.002,0.0	[0.874,0. [0.0023,0	[0.712,0.9 [0.01,0.06	[0.5,0.77 [0.043,0.	[0.78,0.9 [0.0056,0	[0.514,0. [0.035,0.	[0.64,0.87 [0.0165,0	[0.541,0 [0.032,0	[0.56,0.81 [0.0275,0	[0.46,0.7 [0.052,0	[0.56,0 .81] [0.034, 0.14]	[0.80,0. 91] [0.009, 0.05]
At_8	[0.931,0.9 [0.0006,0	[0.78,0.9 [0.004,0.	[0.86,0.96 [0.0019,0	[0.616,0. [0.024,0.	[0.895,0. [0.0014,0	[0.65,0.8 [0.02,0.0	[0.712,0.9 [0.01,0.04	[0.65,0.8 [0.018,0	[0.613,0.8 [0.018,0.0	[0.56,0.8 [0.033,0	[0.78,0 .92] [0.01,0 .05]	[0.54,0. 79] [0.03,0. 096]

Table 3.6.3 Final Decision Matrix

8×12

Step 4 & 5 : Finding the relative closeness coefficient intervals for the alternatives and determining the auxiliary LP model, then utilising Lingo Software for the alternatives.

$O_1^l = 0.945633$ & $O_1^u = 0.989231$

$O_2^l = 0.895501$ & $O_1^u = 0.97368$

$O_3^l = 0.897394$ & $O_3^u = 0.974465$

$O_4^l = 0.766812$ & $O_4^u = 0.909965$

$O_5^l = 0.915512$ & $O_5^u = 0.978268$

$O_6^l = 0.801336$ & $O_6^u = 0.92799$

$O_7^l = 0.865472$ & $O_7^u = 0.959974$

$O_8^l = 0.795743$ & $O_8^u = 0.924$

$O_9^l = 0.801033$ & $O_9^u = 0.929332$

$O_{10}^l = 0.721027$ & $O_{10}^u = 0.883948$

$O_{11}^l = 0.75892$ & $O_{11}^u = 0.904176$

$O_{12}^l = 0.765202$ & $O_{12}^u = 0.90935$

Step 6: Calculating the likelihood $w_p \geq w_q$ of alternatives w_p & w_q by (iv)

Step 7:

Obtaining Likelihood Matrix, which is a pairwise comparison of alternatives from above step

$$P_{lh} = \begin{bmatrix} 0.5 & 0.77 & 0.76 & 1 & 0.69 & 1 & 0.9 & 1 & 1 & 1 & 1 & 1 \\ 0.91 & 0.5 & 0.49 & 0.93 & 0.41 & 0.84 & 0.63 & 0.86 & 0.84 & 1 & 0.96 & 0.94 \\ 0.24 & 0.51 & 0.5 & 0.94 & 0.42 & 0.85 & 0.63 & 0.87 & 0.87 & 1 & 0.97 & 0.95 \\ 0 & 0.06 & 0.06 & 0.5 & 0 & 0.4 & 0.19 & 0.42 & 0.4 & 0.62 & 0.52 & 0.5 \\ 0.31 & 0.59 & 0.58 & 1 & 0.5 & 0.93 & 0.72 & 0.98 & 0.93 & 1 & 1 & 1 \\ 0 & 0.16 & 0.15 & 0.6 & 0.07 & 0.5 & 0.28 & 0.52 & 0.5 & 0.71 & 0.62 & 0.6 \\ 0.1 & 0.37 & 0.36 & 0.81 & 0.28 & 0.72 & 0.5 & 0.74 & 0.71 & 0.93 & 0.57 & 0.82 \\ 0 & 0.14 & 0.13 & 0.58 & 0.04 & 0.48 & 0.26 & 0.5 & 0.48 & 0.7 & 0.6 & 0.58 \\ 0 & 0.16 & 0.16 & 0.6 & 0.07 & 0.5 & 0.29 & 0.52 & 0.5 & 0.72 & 0.62 & 0.6 \\ 0 & 0 & 0 & 0.38 & 0 & 0.28 & 0.07 & 0.3 & 0.28 & 0.5 & 0.41 & 0.4 \\ 0 & 0.04 & 0.03 & 0.48 & 0 & 0.34 & 0.16 & 0.4 & 0.38 & 0.59 & 0.5 & 0.48 \\ 0 & 0.06 & 0.05 & 0.496 & 0 & 0.4 & 0.18 & 0.42 & 0.4 & 0.61 & 0.52 & 0.5 \end{bmatrix}_{12\times12}$$

Step 8:

Calculating the optimal degree θd_p $\forall$ alternatives using equation (iv)

$\theta d_1 = 0.12,\ \theta d_2 = 0.108,\ \theta d_3 = 0.104,\ \theta d_4 = 0.066,\ \theta d_5 = 0.11,\ \theta d_6 = 0.0735,\ \ \theta d_7 = 0.090,\ \theta d_8 = 0.0719,\ \theta d_9 = 0.0738\ ,\ \theta d_{10} = 0.0577,\ \theta d_{11} = 0.0636,\ \theta d_{12} = 0.0654$

Step 9:

The optimal degree is arranged in the decreasing order to determine the best alternative.

$$\theta d_1 > \theta d_5 > \theta d_2 > \theta d_3 > \theta d_7 > \theta d_9 > \theta d_6 > \theta d_8 > \theta d_4 > \theta d_{12} > \theta d_{11} > \theta d_{10}$$

$\theta d_1 (i.e\ Artificial\ intelligence)$ is the best alternative.

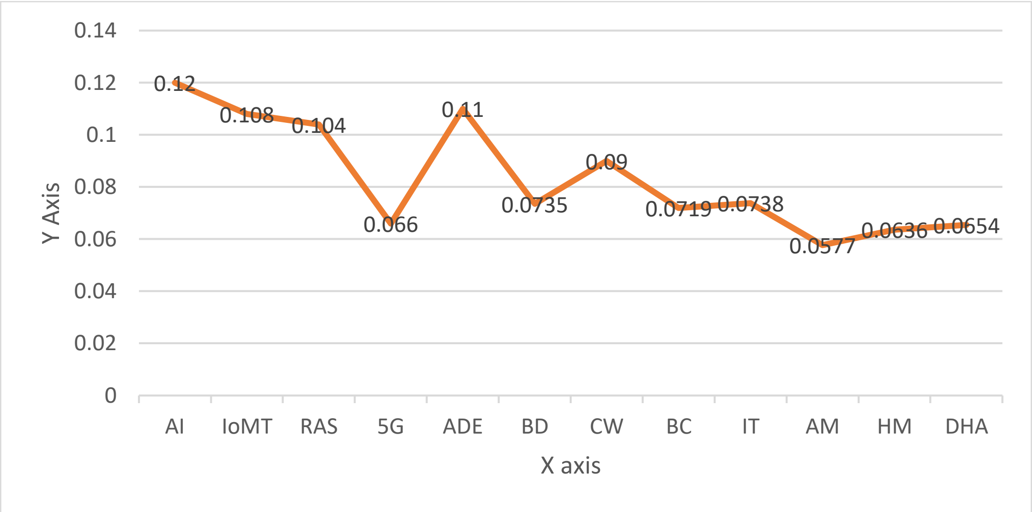

Figure 3.6.1 Optimal degree

3.7 Comparative Study

StartUs Insights, a Data Science Company . It provides an extensive database for researching significant companies and technologies. The following data was published on Nov 2021 and updated on Aug 2023. They had examined a group of 1036 worldwide Startups & Scaleups for this thorough study on top Military Technology Trends. This study based data gives an review of advanced new technologies in military sectors, which Aids in improving tactical choices. From this data, AI is the prominent trend, since more countries spends more money on AI Research[10].

Table 3.7.1 Impact of top 10 Military Technologies Trends & Innovations in 2023

1	Artificial Intelligence	20%
2	Robotics and Autonomous Systems	14%
3	Cyber warfare	10%
4	Immersive Technologies	9%
5	Advanced Defence Equipment	17%
6	Internet of Military Things	10%
7	Additive Manufacturing	6%
8	Big Data & Analytics	6%
9	5G	5%
10	Block chain	3%

Source: StartUs Insights, 2023[10].

3.8 Comparative Study Discussion

In Recent times, there are so many advanced level technologies are used in Military field. In this research we compared 12 technologies with their applications in military , and found AI is the finest technology by their advanced uses and advantages. The results obtained in this research are then compared with the data exists on StartUs Insights [10], and found the results are same.

4.Results

This research work makes an effort to set priorities among the advanced level technologies which are used in Military Sectors. In this study, the ideal values of alternatives & attributes are gathered in the format of IVIF values. The values of both IVIF & FCM matrix are obtained in the format of Linguistic Variables via the expert. In order to do ranking for the alternatives, after resolving the linear programming model, the likelihood function is used. The multi attribute problem is examined as a part of the algorithmic approach, and the examined results are shown in Figure 3.5.1. The results found the finest technology utilised in Army forces as Artificial Intelligence. The obtained results are then compared with the existing data on StartUs Insights[10], and found that the AI is the finest technology in Military Sectors.

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