Airport Cargo System under Intuitionistic Fuzzy Environment

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Abstract— Network analysis is a method used to determines the various sequences of activities concerning a project and the project completion time. The aim of this paper is to demonstrate how to work the intuitionistic fuzzy critical path method to find airport's ground critical operations processes and improve. The method takes in to account the rating methodology of decision makers. Vague parameters in the project network are represented by intuitionistic trapezoidal fuzzy numbers. Intuitionistic fuzzy critical length of the project network is found without defuzzification of the intuitionistic fuzzy activity times. Finally it is expended to execute intuitionistic fuzzy critical path analysis for the airport`s ground operational system.

Key words: Intuitionistic Fuzzy Sets, Intuitionistic Trapezoidal Fuzzy Number, Critical Path Algorithm, Airport Cargo System

I. INTRODUCTION

Critical path method is a network grounded method intended for planning and working of complex project in real world applications. According to the critical path, the decision maker can regulator the time and the cost of the project and improve the competence of resource sharing to ensure the project quality. In many situations, project can be complicated and interesting to manage. There are many cases the activity periods may not be accessible in a specific manner. An different way to deal with vague data is to employ the concept of fuzziness where by imprecise activity times can be represented by fuzzy sets. Fuzzy Set theory proposed by Zadeh[16] can play a significant role to solve such a decision-making problem.

Chen[6] et al. used defuzzification method to find possible critical paths in a fuzzy project network (2001). Chanas and Zielinski[1] suggested a method to make critical path analysis in the network with fuzzy activity times by directly applying the delay principle to the usual criticality perception treated as a role of activity duration time in the network. Styeptsov and Tyshchuk [7] existing a proficient method of calculation of fuzzy time windows for late start and finish times of operations in the problem of fuzzy network. N. Ravi Shankar,[9] proposed new defuzzified formula to find critical path in a fuzzy project network. S. Elizabeth and &Sujatha[12] (2013) introduced new ranking methods to find fuzzy critical path problem for project network. A. Jubai, b. Jing & j. Yang[11] in this paper, the author makes some improvements to the Pal–King fuzzy edge detection algorithm and proposes an algorithm combining improved fuzzy theory and a genetic algorithm for the detection of oil spilled on the sea by remote sensing. Nasution[8] proposed a fuzzy critical path method by considering interactive fuzzy subtraction and by observing that only the non-negative part of the fuzzy numbers can have physical elucidation.

Traffic sticky obtains all the methods like by road, by air, by sea etc. There are many submissions available for intuitionistic fuzzy critical path some of them are airport cargo, harbor cargo and medical filed. Here we focus about airport cargo system. In peak times airport advisors face huge capacity of traffic which will create the problem of facilities and service. If airport authorities are unable to handle problems in airport services at peak times major running complications can arise. Through shifting work practises or using altered transport management approaches in a limited space, positively customer complaints will be kept to a minimum, as well as employing the simplest, cheapest yet most time-saving methods for a given period of time. [14] If an airport terminal's internal operations and service system are inefficient, or if the operational procedures are ineffective, these factors can contribute to flight delays for airlines which may show very expensive in a long-run. This highlights the prominence of the suitable terminal operational techniques and performance pointers in airport management [13]. Though there have been demands to avoid the delays and insufficiencies experienced in airside, landside, and airlines' operations, the existing operation dimension models to cut down airlines' cost only provide vague and uncertain decision- making information. Assume that the fuzzy activity times of all activities in an airport's ground operation network are intuitionistic trapezoidal fuzzy numbers. In general the airlines passenger and cargo ground handling time in many international airports is unstable. In order to improve this instability; the first step is to identify all steps so that the most time-consuming step can be found. To raise the viability, efficiency of the airport cargo terminal, and to increase overall effectiveness; use of fuzzy ICPA will easily find out the critical path by reducing process time essential in the most time-consuming step, the airlines' ground operation efficiency can be upgraded.

So we apply intuitionistic fuzzy critical path method to find out airport's ground critical operation processes and improve. In this paper an existing intuitionistic fuzzy critical path algorithm [19] is used to challenge the problem in fuzzy airport's ground operation decision analysis. The method takes into account the rating approach of decision makers. Thus, by conducting fuzzy or non-fuzzy activity time calculations, decision makers can repeatedly obtain the fuzzy critical path. Therefore, only when customs together moves to meet the needs of the fair can the airports of air cargo ground service is totally established and secure.

This paper is organized as follows: In section 2, basic definitions of intuitionistic fuzzy set theory have been reviewed. Section 3, existing algorithm to find out the intuitionistic fuzzy critical path have been illuminated. Section 4 briefly explained about the application of the proposed algorithm. Section 5 concludes the paper.

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II. PRELIMINARIES

In this section some basic definitions related to intuitionistic fuzzy sets are revised.

A. Intuitionistic Fuzzy Set (Atanassov, Krassimir [17])

Let X be an Universe of discourse, then an Intuitionistic fuzzy set (IFS) A in X is given by $A=\{< x, \mu_A(x), \gamma_A(x) > / x \in X\}$, where the functions $\mu_{A(x)} : X \to [0,1]$ and $\gamma_{A(x)} : X \to [0,1]$ determine the degree of membership and non-membership of the element $x \in X$, respectively and for every $x \in X$, $0 \le \mu_A(x) + \gamma_A(x) \le 1$.

B. Trapezoidal Intuitionistic Fuzzy Number

An Intuitionistic fuzzy number $A = \{< a_1, a_2, a_3, a_4 >< b_1, b_2, b_3, b_4 >\}$ is said to be a trapezoidal intuitionistic fuzzy number if its membership function and non-membership function are given by

$$\mu_A(x) = \begin{cases} \dfrac{(x-a_1)}{(a_2-a_1)} & a_1 \le x \le a_2 \\ 1 & a_2 \le x \le a_3 \\ \dfrac{(x-a_4)}{(a_3-a_4)} & a_3 \le x \le a_4 \end{cases}$$

&

$$\gamma_A(x) = \begin{cases} \dfrac{(x-b_1)}{(b_2-b_1)} & b_1 \le x \le b_2 \\ 1 & b_2 \le x \le b_3 \\ \dfrac{(x-b_4)}{(b_3-b_4)} & b_3 \le x \le b_4 \end{cases}$$

C. Arithmetic Operations on two Trapezoidal Intuitionistic Fuzzy Activity Time

Let $IF\tilde{A}T_1 = (< a_{\mu_1}, b_{\mu_1}, c_{\mu_1}, d_{\mu_1} > < a_{\gamma_1}, b_{\gamma_1}, c_{\gamma_1}, d_{\gamma_1} >)$

and

$IF\tilde{A}T_2 = (< a_{\mu 2}, b_{\mu 2}, c_{\mu_2}, d_{\mu_2} >< a_{\gamma_2}, b_{\gamma_2}, c_{\gamma_2}, d_{\gamma_2} >)$ be any two

Intuitionistic fuzzy activity time (i) Addition operation(+):

$$\text{Let } IF\tilde{A}T_1 + IF\tilde{A}T_2 = (< a_{\mu_1}, b_{\mu_1}, c_{\mu_1}, d_{\mu_1} > < a_{\gamma_1}, b_{\gamma_1}, c_{\gamma_1}, d_{\gamma_1} >) + (< a_{\mu 2}, b_{\mu 2}, c_{\mu_2}, d_{\mu_2} > < a_{\gamma_2}, b_{\gamma_2}, c_{\gamma_2}, d_{\gamma_2} >)$$

$$= \left\langle \begin{matrix} (a_{\mu_1} + a_{\mu 2}, b_{\mu_1} + b_{\mu 2}, c_{\mu_1} + c_{\mu_2}, d_{\mu_1} + d_{\mu_2}); \\ (a_{\gamma_1} + a_{\gamma_2}, b_{\gamma_1} + b_{\gamma_2}, c_{\gamma_1} + c_{\gamma_2}, d_{\gamma_1} + d_{\gamma_2}) \end{matrix} \right\rangle$$

D. Subtraction Operation (-)

$$\text{Let } F\tilde{A}T_1 - F\tilde{A}T_2 = (< a_{\mu_1}, b_{\mu_1}, c_{\mu_1}, d_{\mu_1} > < a_{\gamma_1}, b_{\gamma_1}, c_{\gamma_1}, d_{\gamma_1} >) + (< a_{\mu 2}, b_{\mu 2}, c_{\mu_2}, d_{\mu_2} > < a_{\gamma_2}, b_{\gamma_2}, c_{\gamma_2}, d_{\gamma_2} >)$$

$$= \left\langle \begin{matrix} (a_{\mu_1} - d_{\mu 2}, b_{\mu_1} - c_{\mu 2}, c_{\mu_1} - b_{\mu_2}, d_{\mu_1} - a_{\mu_2}); \\ (a_{\gamma_1} - d_{\gamma_2}, b_{\gamma_1} - c_{\gamma_2}, c_{\gamma_1} - b_{\gamma_2}, d_{\gamma_1} - a_{\gamma_2}) \end{matrix} \right\rangle$$

1) Calculating Intuitionistic Fuzzy Time Values And Critical Path Analysis In Intuitionistic Fuzzy Project Network[18]

An Intuitionistic fuzzy project network is an acyclic directed graph, where the vertices denote events, and the direct edges denote the activities, to be performed in a project network. An intuitionistic fuzzy project network is represented by $\tilde{N} =< (\tilde{v}_\mu, \tilde{v}_\gamma)(\tilde{A}_\mu, \tilde{A}_\gamma)(\tilde{T}_\mu, \tilde{T}_\gamma) >$.

Let $\tilde{v} = (\tilde{v}_\mu, \tilde{v}_\gamma) =< (\tilde{v}_{\mu 1}, \tilde{v}_{\mu 2} .... \tilde{v}_{\mu n})(\tilde{v}_{\gamma 1}, \tilde{v}_{\gamma 2} .... \tilde{v}_{\gamma n}) >$ be the set of intuitionistic fuzzy vertices, where $(\tilde{v}_{\mu 1}, \tilde{v}_{\gamma 1})$ and $(\tilde{v}_{\mu n}, \tilde{v}_{\gamma n})$ are the tail and head events of the project, and each $(\tilde{v}_{\mu i}, \tilde{v}_{\gamma i})$ belongs to some path from $(\tilde{v}_{\mu 1}, \tilde{v}_{\gamma 1})$ to $(\tilde{v}_{\mu n}, \tilde{v}_{\gamma n})$ .Let $\tilde{A} \subset \tilde{V} \times \tilde{V}$ be the set of a directed edge $\tilde{A} = \left\{ \left\langle \begin{matrix} (a_{\mu i j}, a_{\gamma i j}) = (v_{\mu i}, v_{\mu j})(v_{\gamma i}, v_{\gamma j}) / \text{for} \\ v_{\mu i}, v_{\mu j}, v_{\gamma i}, v_{\gamma j} \in \tilde{V} \end{matrix} \right\rangle \right\}$ that represents the activities to be performed in the project. Activity $(\tilde{a}_{\mu i j}, \tilde{a}_{\gamma i j})$ is then represented by one and only one, arrow with tail event $(\tilde{v}_{\mu i}, \tilde{v}_{\gamma i})$ and a head event $(\tilde{v}_{\mu j}, \tilde{v}_{\gamma j})$. For each activity $(\tilde{a}_{\mu i j}, \tilde{a}_{\gamma i j})$, an intuitionistic fuzzy number $\tilde{t}_{ij} \in \tilde{T}$ is defined as the intuitionistic fuzzy time required for the completion of $(\tilde{a}_{\mu i j}, \tilde{a}_{\gamma i j})$. A critical path is the longest path from the initial event $(\tilde{v}_{\mu 1}, \tilde{v}_{\gamma 1})$ to the terminal event $(\tilde{v}_{\mu n}, \tilde{v}_{\gamma n})$ of the project network, and an activity $(\tilde{a}_{\mu i j}, \tilde{a}_{\gamma i j})$ on a critical path is called a critical activity.

E. Notations

N = the set of all nodes in a project network.

EST = Earliest Starting time

- $\tilde{A}_{\mu i j}$ = The activity between nodes i and j for membership function.
- $\tilde{A}_{\gamma i j}$ = The activity between nodes i and j for non-membership function.
- $IF\tilde{E}T_{\mu i j}$ = Intuitionistic fuzzy activity time for membership function.
- $IF\tilde{E}T_{\gamma i j}$ = Intuitionistic fuzzy activity time for non-membership function.
- $IF\tilde{E}S_{\mu j}$ = The earliest starting intuitionistic fuzzy time for membership function of node j.
- $IF\tilde{E}S_{\gamma j}$ = The earliest starting intuitionistic fuzzy time for non-membership function of node j.
- $IF\tilde{L}F_{\mu i}$ = The latest finishing intuitionistic fuzzy time for membership function of node i.
- $IF\tilde{L}F_{\gamma i}$ = The latest finishing intuitionistic fuzzy time for non-membership function of node i.
- $IF\tilde{T}S_{\mu i j}$ =The total slack intuitionistic fuzzy time of $\tilde{A}_{\mu i j}$
- $IF\tilde{T}S_{\gamma i j}$ = The total slack intuitionistic fuzzy time of $\tilde{A}_{\gamma i j}$

P_k= the k^{th} Intuitionistic fuzzy path.

TF = Total float

IFCPM (P_k) – The total slack intuitionistic fuzzy time of path P_k in a project network.

T_{ij} = the Intuitionistic fuzzy activity time

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F. An Existing Algorithm for Intuitionistic Fuzzy Critical Path [19]

In this section an existing algorithm is proposed for finding the intuitionistic fuzzy critical path. The existing algorithm has given in the format of table 1 and flowchart is shown in Fig. 1.

1	Construct a project network G(V,E),
2	Estimate the intuitionistic fuzzy activity time,
3	Let $IF\tilde{E}S_{\mu 1} = (0,0,0,0)$ & $IF\tilde{E}S_{\gamma 1} = (0,0,0,0)$
4	calculate $IF\tilde{E}S_{\mu j}$ & $IF\tilde{E}S_{\gamma j}$ $IF\tilde{E}S_{\mu j} = Max_i \left[IF\tilde{E}S_{\mu i}(+) F\tilde{E}T_{\mu ij} \right]$, i = number of preceding nodes , $j \neq 1, j \in N$ $IF\tilde{E}S_{\gamma j} = Min_i \left[IF\tilde{E}S_{\gamma i}(+) F\tilde{E}T_{\gamma ij} \right]$, i = number of preceding nodes , $j \neq 1, j \in N$
5	Let $IF\tilde{L}F_{\mu n} = IF\tilde{E}S_{\mu n}$ & $IF\tilde{L}F_{\gamma n} = IF\tilde{E}S_{\gamma n}$,
6	calculate $IF\tilde{L}F_{\mu i}$ & $IF\tilde{L}F_{\gamma i}$ $IF\tilde{L}F_{\mu i} = Min_j \left[IF\tilde{L}F_{\mu j}(-) IF\tilde{E}T_{\mu ij} \right]$, $i \neq n, i \in N$, j = number of succeeding nodes. $IF\tilde{L}F_{\gamma i} = Max_j \left[IF\tilde{L}F_{\gamma j}(-) IF\tilde{E}T_{\gamma ij} \right]$, $i \neq n, i \in N$, j = number of succeeding nodes .
7	Calculate $IF\tilde{T}S_{\mu ij}$ & $IF\tilde{T}S_{\gamma ij}$, $IF\tilde{T}S_{\mu ij} = IF\tilde{L}F_{\mu j}(-)(IF\tilde{E}S_{\mu i}(+)IF\tilde{E}T_{\mu ij})$ $IF\tilde{T}S_{\gamma ij} = IF\tilde{E}S_{\gamma i}(-)(IF\tilde{L}F_{\gamma j}(+)IF\tilde{E}T_{\gamma ij})$ & $1 \leq i < j \leq n; i, j \in N$
8	Find all the possible paths,
9	calculate $IFCPM(P_{\mu k})$ & $IFCPM(P_{\gamma k})$ $IFCPM(p_{\mu_k}) = \sum_{1 \leq i < j \leq n} IF\tilde{T}S_{\mu ij} p_{\mu_k} \in P$ & $i, j \in P_{\mu_k}$ $IFCPM(p_{\gamma_k}) = \sum_{1 \leq i < j \leq n} IF\tilde{T}S_{\gamma ij} p_{\gamma_k} \in P$ $i, j \in P_{\mu_k}$ $IFCPM(p_c) = \max \left\{ \begin{matrix} IFCPM(p_{\mu k}, p_{\gamma k}) / p_{\mu k}, p_{\gamma k} \in P, \\ k = 1 \text{ to } m \end{matrix} \right\}$
10	Identify the intuitionistic fuzzy critical path.

Table 1: Algorithm for Intuitionistic Fuzzy Critical Path [19]

III. APPLICATION

In this section intuitionistic fuzzy project network problems are presented to demonstrate the computational process of intuitionistic fuzzy critical path analysis proposed above.

A. Step 1

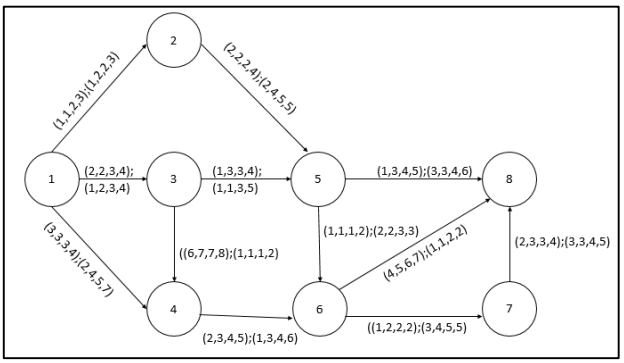

Fig. 1: Computational Process

B. Step 2

Activity	Description	Intuitionistic fuzzy activity duration
1-2	Customs office cargo clearance with manuscript approval	(1,1,2,3) (1,2,2,3)
1-3	Customs office clearance with examination	(2,2,3,4)(1,2,3,4)
1-4	Customs office cargo sanction with document approval and inspection	(3,3,3,4) (2,4,5,7)
2-5	Customs office inspection-exempt cargo clearance	(2,3,3,4) (2,4,5,5)
3-4	Customs office investigation released cargo clearance	(6,7,7,8) (1,1,1,2)
3-5	Customs office after discharging cargo and packing cargo coming up for packing	(1,3,3,4) (1,1,3,5)
4-6	Customs office after cargo clearance with inspection and coming up for loading	(2,3,4,5) (1,3,4,6)
5-6	Customs office after check-up relieved cargo clearance, releasing cargo and packing cargo waiting for packing.	(1,1,1,2) (2,2,3,3)
5-8	Customs office after cargo clearance with file approval, releasing cargo waiting for heaping.	(1,3,4,5) (3,3,4,6)
6-7	Customs headquarters after cargo clearance with document agreement, stuffing cargo to come for stacking.	(1,2,2,2) (3,4,5,5)
6-8	Customs office after cargo consent with inspection, discharging cargo in store for loading.	(4,5,6,7) (1,1,2,2)
7-8	Customs office after cargo approval with scrutiny, filling cargo for heaping.	(2,3,3,4) (3,3,4,5)

Table 2: Activity Duration of Each Activity in an Intuitionistic Fuzzy Project Network

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C. Step 3

Let us take the earliest starting intuitionistic fuzzy time are $IF\tilde{E}S_{\mu 1}$ & $IF\tilde{E}S_{\gamma 1}$

Membership function

Let $IF\tilde{E}S_{\mu 1} = (0,0,0,0)$

Non – membership function

$IF\tilde{E}S_{\gamma 1} = (0,0,0,0)$

D. Step 4:

The remaining earliest starting intuitionistic fuzzy times are calculated using 4 from table 1.

E. Step 5

Let us take the latest finishing intuitionistic fuzzy time are, Membership function

$$IF\tilde{L}F_{\mu n} = IF\tilde{E}S_{\mu n}$$

Non - Membership function

$$IF\tilde{L}F_{\gamma n} = IF\tilde{E}S_{\gamma n}$$

F. Step 6

The remaining latest finishing intuitionistic fuzzy times are calculated using 6 from table 1.

G. Step 7

Activity (i-j) i<j	Duration $IF\tilde{E}T_{\mu ij}$	$IF\tilde{E}S_{\mu i}$	$IF\tilde{L}F_{\mu j}$	$IF\tilde{T}S_{\mu ij}$
1-2	(1,1,2,3)	(0,0,0,0)	(1,7,11,17)	(-2,5,12,16)
1-3	(2,2,3,4)	(0,0,0,0)	(-6,0,5,12)	(-10,-3,3,10)
1-4	(3,3,3,4)	(0,0,0,0)	(2,7,12,18)	(-2,4,9,15)
2-5	(2,3,3,4)	(1,1,2,3)	(5,10,14,19)	(-2,5,10,16)
3-4	(6,7,7,8)	(2,2,3,4)	(2,7,12,18)	(-10,-3,3,10)
3-5	(1,3,3,4)	(2,2,3,4)	(5,10,14,19)	(-3,4,9,16)
4-6	(2,3,4,5)	(8,9,10,12)	(7,11,15,20)	(-10,-3,3,10)
5-6	(1,1,1,2)	(3,5,6,8)	(7,11,15,20)	(-3,4,9,16)
5-8	(1,3,4,5)	(3,5,6,8)	(14,17,20,24)	(1,7,12,20)
6-7	(1,2,2,2)	(10,12,14,17)	(10,14,17,22)	(-9,-2,3,10)
6-8	(4,5,6,7)	(10,12,14,17)	(14,17,20,24)	(-10,-3,3,10)
7-8	(2,3,3,4)	(11,14,16,19)	(14,17,20,24)	(-9,-2,3,11)

Table 3: Total Slack Intuitionistic Fuzzy Time for Each Activity In An Intuitionistic Fuzzy Project Network And Critical Path For Membership Function

Activity (i-j) i<j	Duration $IF\tilde{E}T_{\mu ij}$	$IF\tilde{E}S_{\mu i}$	$IF\tilde{L}F_{\mu j}$	$IF\tilde{T}S_{\mu ij}$
1-2	(1,2,2,3)	(1,2,2,3)	(-10,-3,3,10)	(-12,-3,3,12)
1-3	(1,2,3,4)	(1,2,3,4)	(-10,-3,3,10)	(-13,-4,4,13)
1-4	(2,4,5,7)	(2,3,4,6)	(-10,-3,3,10)	(-15,-5,3,14)
2-5	(2,4,5,5)	(2,3,6,9)	(-7,-2,3,9)	(-12,-5,4,14)
3-4	(1,1,1,2)	(2,3,4,6)	(-6,0,5,11)	(-11,-3,3,11)
3-5	(1,1,3,5)	(2,3,6,9)	(-6,0,5,11)	(-14,-5,5,14)
4-6	(1,3,4,6)	(3,6,8,12)	(-4,1,6,12)	(-15,-4,4,15)
5-6	(2,2,3,3)	(3,6,8,12)	(-2,3,7,11)	(-11,-4,3,12)
5-8	(3,3,4,6)	(4,7,10,14)	(-2,3,7,11)	(-13,-4,4,13)
6-7	(3,4,5,5)	(6,10,13,17)	(-1,3,7,11)	(-10,-2,6,15)
6-8	(1,1,2,2)	(4,7,10,14)	(2,5,9,13)	(-11,-4,4,11)
7-8	(3,3,4,5)	(6,10,13,17)	(-1,3,7,11)	(-10,-1,7,15)

Table 4: Total Slack Intuitionistic Fuzzy Time for Each Activity in an Intuitionistic Fuzzy Project Network and Critical Path for Non-Membership Function

H. Step 8 & Step 9

Find all possible paths and calculate IFCPM ($p_{\mu k}$) & IFCPM($p_{\gamma k}$).

S. No	All paths	IFCPM($p_{\mu k}$) k=1 to 10 (Membership function)	IFCPM($p_{\gamma k}$) k=1 to 10 (Non-membership function)
1	1→2→5→6→7→8	(-25,10,37,69)	(-55,-15,23,78)
2	1→2→5→6→8	(-17,11,34,58)	(-46,-16,14,49)
3	1→2→5→8	(-3,17,34,52)	(-37,-12,11,39)
4	1→3→4→6→7→8	(-48,-11,12,41)	(-59,-14,24,69)
5	**1→3→4→6→8**	**(-40,-12,12,40)**	**(-50,-15,15,50)**
6	1→3→5→8	(-12,8,24,46)	(-40,-13,13,40)
7	1→3→5→6→7→8	(-34,1,27,63)	(-58,-16,25,69)
8	1→3→5→6→8	(-26,2,24,52)	(-49,-17,16,50)
9	1→4→6→7→8	(-30,-3,18,46)	(-50,-12,20,59)
10	1→4→6→8	(-22,-2,15,35)	(-41,-13,11,40)

Table 5: The Total Slack Intuitionistic Fuzzy Time of Path $P_{\mu k}$&$P_{\gamma k}$

I. Step 10

Hence the intuitionistic fuzzy critical path is P_5. That is 1→3→4→6→8. Intuitionistic fuzzy critical path and intuitionist fuzzy critical path length are useful information for the project to make decision in design and scheduling complex projects.

IV. Conclusion

In this paper we used intuitionistic fuzzy critical path algorithm to tackle the problem in airport's ground operation decision analysis. Here we used intuitionistic fuzzy critical path method to find airport's ground critical operations methods. The result of this study suggests redesigning airports' cargo handling processes can improve airlines' freight service performance in terms of freight

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handling speed, cargo service quality, an, and freight handling cost in hub airports.

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