Retraction

Retraction: Minimizing Rental Cost with Continuous Machine Operation Using Ginni Simpson Index (*IOP Conf. Ser.: Mater. Sci. Eng. 1145 012087*)

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This article (and all articles in the proceedings volume relating to the same conference) has been retracted by IOP Publishing following an extensive investigation in line with the COPE guidelines. This investigation has uncovered evidence of systematic manipulation of the publication process and considerable citation manipulation.

IOP Publishing respectfully requests that readers consider all work within this volume potentially unreliable, as the volume has not been through a credible peer review process.

IOP Publishing regrets that our usual quality checks did not identify these issues before publication, and have since put additional measures in place to try to prevent these issues from reoccurring. IOP Publishing wishes to credit anonymous whistleblowers and the Problematic Paper Screener [1] for bringing some of the above issues to our attention, prompting us to investigate further.

[1] Cabanac G, Labbé C and Magazinov A 2021 arXiv:2107.06751v1

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Minimizing Rental Cost with Continuous Machine Operation Using Ginni Simpson Index

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Abstract. This paper studies scheduling problem of two machines with uncertain dispensation time. Our objective of study is to attain a schedule which makes idle time of machines equal to zero and reduces the rental cost of machines. Here processing time is uncertain. To deal with uncertainty Ginni Simpson Index is used. A numerical example is employed to make clear the given algorithm.

Keywords: Flow shop scheduling, Elapsed time, continuous machine operation, Ginni Simpson index.

1. Introduction
Planning and scheduling plays an important role for success in service and manufacturing industries. In some scheduling problems, several applications exist where it is required that some components perform consecutively. The working of machines can’t be stopped when started processing of jobs because their interruption causes decrease in benefits and increase in cost. This increase in cost or decrease in benefits may be due to expensive parts of machines which are used in processing and so manufacturing system does not allow idling of such costly machines. Sometimes the situation can occur when an industrialist undertakes the project of processing the jobs but does not have his own machines. Now he will hire the machines on rent with the objective to complete the task with minimum total rental cost and zero idle time of machines [1-5].

As we are aware that total rental cost for flow shop scheduling problem with two

\[ k \text{ machines } = \sum_{m=1}^{k} p(m,n) + I(m,n)\times C_n \]

Where \( p(m,n) \) represents the dispensation time of \( m^{th} \) job on \( n^{th} \) machine, \( I(m, n) \) represents the idle time of machine \( n \) for job \( m \) and \( C_n \) is hiring price of \( n^{th} \) machine for per unit time. The processing time \( p(m,n) \) and hiring cost \( C_n \) are fixed so that we can reduce only the idle time \( I(m, n) \) for \( m=1,2,3,\ldots k \) and \( n=1,2 \). So if idle time of machines is reduced or made zero then rental cost of the machines will also be reduced [10].

Let \( P=(P_1,P_2,P_3,\ldots,P_n) \); \( P_i\geq 0, i=1,2,3\ldots n, n\geq 2 \)

\[ P_i = 1 \text{, is a set of discrete finite } \]

and

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n array probability distribution. Then we define Gini Simpson [6] index of diversity by 

\[ (P) = 1 - \sum_{i=1}^{n} P_i^2. \]

**Practical Application:**

There are various situations where no idle scheduling is required. Some situations come from sectors where machines used in production are less expensive but these cannot be stopped and restarted easily [7-9]. Consider the example of Ceramic roller kilns, this type of machine requires several days when we stop this between processing and then restart it. So idling is not an option hence requires no idle scheduling [11].

**Rental Policy:** Generally, three types of rental policies exist:

- **Policy 1:** All machines are hired at same starting time and are returned at same time.
- **Policy 2:** All machines are hired at the same time and are returned when processing is done on them.
- **Policy 3:** All machines are hired as and when required and are returned as and when processing is done on them and they are no longer required [4].

In the present problem, we have used the policy 3 because our objective to have zero idle time of machines and under policy 1 and policy 2 all machines are hired at one time i.e. in the starting of processing [12], [13]. First machine will start processing in the starting but machine 2 will be idle. Therefore, our aim can’t be attained under policy 1 and policy 2.

**2. Problem Formulation**

Consider k jobs and two machines scheduling problem whose uncertain dispensation time is given by \( \mu_{ij} \) and \( \eta_{ij} \) where \( i=1,2,3 \) and \( j=1,2,3,...,k \) on machines \( \eta \) and \( \mu \) respectively. Let \( C_1 \) and \( C_2 \) be the renting cost for one unit time of machines \( \eta \) and \( \mu \) respectively [8]. Our goal is to obtain a schedule which makes the machines idle time zero and reduces the hiring cost as shown in table 1.

| Machines | Jobs | 1   | 2   | 3   | 4   | -   | K   |
|----------|------|-----|-----|-----|-----|-----|-----|
| \( \eta \) | \( \eta_{i1} \) | \( \eta_{i2} \) | \( \eta_{i3} \) | \( \eta_{i4} \) | -   | \( \eta_k \) |
| \( \mu \) | \( \mu_{i1} \) | \( \mu_{i2} \) | \( \mu_{i3} \) | \( \mu_{i4} \) | -   | \( \mu_k \) |

Table 1. schedule of machines
3. Numerical Example:

Take a 5 job and 2 machine scheduling problem whose uncertain processing time are represented by $\eta_{ij}$ and $\mu_{ij}$ where $i=1,2,3$ and $j=1,2,...,5$. The rate of rent for per unit time $ij$ for $\eta$ and $\mu$ are 6 and 8 units [2].

In matrix form this problem may be stated as shown in tables 2 and 3. Table 4 states Gini simpsons index and Johnson’s Technique.
### Table 2. Matrix 1

| JOBS | MACHINE $\eta$ | MACHINE $\mu$ |
|------|----------------|---------------|
| 1    | (4,6,8)        | (7,9,11)      |
| 2    | (7,9,10)       | (6,8,9)       |
| 3    | (8,11,13)      | (3,5,6)       |
| 4    | (3,7,9)        | (2,4,5)       |
| 5    | (4,5,6)        | (5,7,11)      |

**STEP 1 - Calculate**

$$\eta_{ij} = \frac{\eta_i}{\sum_{i=1}^{3} \eta_i}$$

and

$$\mu_{ij} = \frac{\mu_i}{\sum_{i=1}^{3} \mu_i}$$

where $i=1,2,3$ and $j=1,2,..5$

### Table 3. Matrix 2

| JOBS | MACHINE $\eta$ | MACHINE $\mu$ |
|------|----------------|---------------|
| 1    | $\left(\begin{array}{c} 4 \\ 6 \\ 8 \\ 18 \\ 18 \\ 18 \end{array}\right)$ | $\left(\begin{array}{c} 7 \\ 9 \\ 11 \\ 27 \\ 27 \\ 27 \end{array}\right)$ |
| 2    | $\left(\begin{array}{c} 7 \\ 9 \\ 10 \\ 26 \\ 26 \\ 26 \end{array}\right)$ | $\left(\begin{array}{c} 6 \\ 8 \\ 9 \\ 23 \\ 23 \\ 23 \end{array}\right)$ |
| 3    | $\left(\begin{array}{c} 8 \\ 11 \\ 13 \\ 32 \\ 32 \\ 32 \end{array}\right)$ | $\left(\begin{array}{c} 3 \\ 5 \\ 6 \\ 14 \\ 14 \\ 14 \end{array}\right)$ |
| 4    | $\left(\begin{array}{c} 3 \\ 7 \\ 9 \\ 19 \\ 19 \\ 19 \end{array}\right)$ | $\left(\begin{array}{c} 2 \\ 4 \\ 5 \\ 11 \\ 11 \\ 11 \end{array}\right)$ |
| 5    | $\left(\begin{array}{c} 4 \\ 5 \\ 6 \\ 15 \\ 15 \\ 15 \end{array}\right)$ | $\left(\begin{array}{c} 5 \\ 7 \\ 11 \\ 23 \\ 23 \\ 23 \end{array}\right)$ |

We observe that $\sum_{i=1}^{3} \eta_{ij} = 1$ and $\sum_{i=1}^{3} \mu_{ij} = 1$.

**STEP 2 - Using Gini Simpson’s index**

$$\lambda_i = [1 - \sum_{j=1}^{3} \eta_{ij}^2]$$

and

$$\omega_i = [1 - \sum_{j=1}^{3} \mu_{ij}^2]$$

where $i=1,2,..5$
Table 4. Gini Simpson’s index and Johnson’s Technique

| Jobs | Machine η   | Machine μ   |
|------|-------------|-------------|
| 1    | 208         | 478         |
|      | 324         | 729         |
| 2    | 446         | 348         |
|      | 676         | 529         |
| 3    | 670         | 126         |
|      | 1024        | 196         |
| 4    | 222         | 76          |
|      | 361         | 121         |
| 5    | 148         | 334         |
|      | 235         | 529         |

**STEP 3** - Using Johnson’s Technique, we get optimal sequence - 4,1,2,3,5

**STEP 4** - Prepare the in –Out table for sequence obtained in step 3 is shown in Table 5.

Table 5. Out table for sequence

| Jobs | In-Out | In-Out   |
|------|--------|----------|
| 4    | 0 - 0.614 | 0.614 – 1.242 |
| 1    | 0.614 – 1.255 | 1.255 – 1.910 |
| 2    | 1.255 – 1.914 | 1.914 – 2.571 |
| 3    | 1.914 – 2.568 | 2.571 – 3.213 |
| 5    | 2.568 – 3.225 | 3.225 – 3.856 |

**STEP 5** - Calculate latest time $L_2$ to hire machine $μ$ by $L_2 = 3.856 - (3.213) = 0.643$

**STEP 6** and **STEP 7** - Taking $K_2$ as starting time for Machine $μ$, prepare In Out table is shown in Table 6.
Table 6. In Out table

| Jobs | In- Out | In-Out |
|------|---------|--------|
| 1    | 0 - 0.614 | 0.643 – 1.271 |
| 2    | 0.614 – 1.255 | 1.271 – 1.926 |
| 3    | 1.255 – 1.914 | 1.926 – 2.583 |
| 4    | 1.914 – 2.568 | 2.583 – 3.225 |
| 5    | 2.568 – 3.225 | 3.225 – 3.856 |

**STEP 8:**
\[
R(S) = \sum_{i=1}^{n} \lambda_i * C_1 + U_2(S)* C_2
\]
\[
= 3.225 * 6 + (3.856 - 0.643)* 8
\]
\[
= 19.35 + 25.704 = 45.054
\]

4. Conclusion
In the present paper, A new knowledge measure in fuzzy environment has been introduced. We have also considered an example to explain the given algorithm. With the help of this algorithm, we have neglected the idle time and reduced the rental cost. This study can be further done by considering certain parameters such as set up time, breakdown interval etc.

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