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Multi-Factor Strategy of Robotics Investment Using Weighted Induced Method

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Abstract:

This paper studies intuitionistic fuzzy (IF) decision making in robotics investment using an integrated approach to deal with uncertainty international environment. Firstly, an IF induced generalized ordered weighted averaging distance operator is introduced, which covers numerous IF aggregations distance operators. Then, two more generalized operators named IF quasi induced OWAD (Quasi-IFIOWAD) and IF induced generalized hybrid average distance (IFIGHAD) operator are presented. Furthermore, the method of Multi-factor strategy using above operators is introduced to IF decision making problem. Finally, a real case of robotics investment portfolio is present to show the effect of the method and robot industry developing trend is given. It is pointed out that there is a lot of room for domestic substitution. It is pointed out that there is a lot of room for domestic substitution.

Keywords*: Intuitionistic fuzzy, Multi-factor strategy, Robotics investment, Weighted induced method.*

I. INTRODUCTION

Investors often make decision to choose a suitable portfolio strategy, especially in the robotics enterprises investment in China. For example, the robotics investment includes the selection of technology, equipment or product portfolio which should be considered from finite feasible alternatives according to the evaluated attributes' preference information given by investors. Under the influence of emotion, environment and the limit of brain power, ordinary investors usually can not give the exact weight of attributes and the values of evaluation. The fuzzy set (FS) theories are firstly presented by Zadeh (1965) to process the unsure problem. In

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the further, the intuitionistic FS named IFS is presented to remove the drawback of typical FS using membership functions and non-membership functions. Now, the researchers pay more attention to IFS in group decision making area. Yujie Liu (2017) presented an assurance induced suggestion mechanism to give individualized advice for conflict experts to achieve better agreement level [1]. Sidong Xian et al. (2018) proposed the intuitionistic fuzzy interval - valued linguistic entropic combined weighted averaging operator for the different attribute linguistic association decision making [2].

The previous study has proven that the IFS are effective to investment portfolio under unclear environment. However, it cannot address the qualitative reference problem. Wang (2010) first defined ILS named intuitionistic linguistic set which combines the linguistic term and IFS to deal uncertain information. Then, the aggregation operator of ILS and relevant approaches is the focus of research now. Such as, the use of dependant aggregation operators in ILS circumstances is discussed by Liu (2013) [3]. The measures of ordered weighted space among IL sets are investigated by Su (2014). To assist ILS information, the weighted induced aggregation operator is presented by Liu et al. (2017) used for low-carbon supplier selection.

To developing the application of the ILS, we give an ILS aggregated approach and use it in robotics investing in China. Then， Multi-factor Alpha strategy of robotics investment is given using ILS method and PE, PS, Pb and other factors published information which select the stocks in robotics theme with major features and special object. In the end, the method is verified by using robotics investment decision problem.

II. PREPARATIONS

The IOWA is defined to expanse OWA named ordered weighted averaging operator whose improvements are reordering step with order-inducing variables, as is shown as follow:

Definition 1. An IOWA operator of dimension n is a mapping IOWA: $R^n \times R^n \to R$ that has an associated weighting W with $w_j \in [0,1]$ and $\sum_{j=1}^{n} w_j = 1$ such that:

$$IOWA\left(\langle u_1, a_1\rangle, \langle u_2, a_2\rangle, ..., \langle u_n, a_n\rangle\right) = \sum_{j=1}^{n} w_j b_j \tag{1}$$

Where b_j is a_i value of the IOWA pair $\langle u_i, a_i\rangle$ having the j the largest u_i, u_i is the order inducing variable and a_i is the argument variable.

The IGOWAD operators are distance measures using the IOWA operator in the normalization process of the Minkowski distance, which is defined as follows for the sets of $A = \{a_1, a_2, ..., a_n\}$ and $B = \{b_1, b_2, ..., b_n\}$

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Definition 2. An IGOWAD operator of dimension n is a mapping $f: R^n \times R^n \times R^n \to R$ that has an associated weighting W with $w_j \in [0,1]$ and $\sum_{j=1}^{n} w_j = 1$ such that:

$$f\left((u_1,a_1,b_1),(u_2,a_2,b_2),...,(u_n,a_n,b_n)\right)=\left(\sum_{j=1}^{n} w_j d_j^{\lambda}\right)^{1/\lambda} \quad (2)$$

where $|a_i - b_i|$ is the argument variable represented by individual distances, λ is a parameter such that $\lambda \in (-\infty,+\infty)$. Especially, if $\lambda = 1$, then the IOWAD is got. if $\lambda = 2$, the IEOWAD operator is got, d_j is the $|a_i - b_i|$ value of the IGOWAD triplet (u_i, a_i, b_i) having the j th largest u_i, u_i is the order inducing variable.

IGOWAD operators are used to handle exact data. But investment always cannot acquire complete information for the information of the investor is uncertain. To IFS, the fundamental components are IFNs named intuitionistic fuzzy numbers which are very helpful in describing variability and impreciseness of investment problem. In the paper, the extension of the IGOWAD named IFIGOWAD operator is proposed as follow.

III. THE OPERATORS OF INDUCED INTUITIONISTIC FUZZY GENERALIZED AGGREGATION DISTANCE

At first, the IFS are introduced, and then IFIGOWAD operator is developed.

Definition 3. Let a set $X = \{x_1, x_2, ..., x_n\}$ be fixed, an IFS A in X is given as following:

$$A = \{\langle x, \mu_A(x), v_A(x)\rangle | x \in X\}$$

Where $\mu_A : X \to [0,1]$ $v_A : X \to [0,1]$ decide the degree of the membership and non-membership of the factor $x \in X$, separately, $0 \le \mu_A(x) + v_A(x) \le 1$, $x \in X$. $\alpha = (\mu_\alpha, v_\alpha)$ is named as IFN which means intuitionistic fuzzy number, $\mu_\alpha \in [0,1]$, $v_\alpha \in [0,1]$, $\mu_\alpha + v_\alpha \le 1$.

There are some operations and relations of IFNs are introduced are shown as follow: for any IFNs $\alpha = (\mu_\alpha, v_\alpha), \alpha_1 = (\mu_{\alpha_1}, v_{\alpha_1})$ and $\alpha_2 = (\mu_{\alpha_2}, v_{\alpha_2})$, then

(1) $\alpha_1 + \alpha_2 = (\mu_{\alpha_1} + \mu_{\alpha_2} - \mu_{\alpha_1} \cdot \mu_{\alpha_2}, v_{\alpha_1} \cdot v_{\alpha_2})$

(2) $\lambda\alpha = (1-(1-\mu_\alpha)^\lambda, {v_\alpha}^\lambda)$, $\lambda > 0$.

Let $\alpha_1 = (\mu_{\alpha_1}, v_{\alpha_1})$ and $\alpha_2 = (\mu_{\alpha_2}, v_{\alpha_2})$ be two IFNs, an intuitionistic fuzzy distance is determined as follows:

Definition 4. Let $\alpha_1 = (\mu_{\alpha_1}, v_{\alpha_1})$ and $\alpha_2 = (\mu_{\alpha_2}, v_{\alpha_2})$ be two IFNs, then

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$$d(\alpha_1,\alpha_2)=\frac{1}{2}\left(\left|\mu_{\alpha_1}-\mu_{\alpha_2}\right|+\left|\nu_{\alpha_1}-\nu_{\alpha_2}\right|\right)$$ □

is called the distance between α_1 and α_2.

Based on the IGOWAD operator and the laws of intuitionistic fuzzy set, now we can develop the IFIGOWAD operator. Let Ω be all IFNs set, $A=(\alpha_1,\alpha_2,...,\alpha_n)$ and $B=(\beta_1,\beta_2,...,\beta_n)$ be two sets of IFNs, then it can be defined as following.

Definition 5. An IFIGOWAD operator of dimension n is a mapping *IFIGOWAD*: $R^n\times\Omega^n\times\Omega^n\to R$ that has an associated weighting W with $w_j\in[0,1]$ and $\sum_{j=1}^{n}w_j=1$ such that:

$$IFIGOWAD\left(\langle u_1,\alpha_1,\beta_1\rangle,...,\langle u_n,\alpha_n,\beta_n\rangle\right)=\left(\sum_{j=1}^{n}w_j d_j^{\lambda}\right)^{1/\lambda}$$ □

where d_j is $\left|\alpha_i-\beta_i\right|$ value of the IFIGOWAD pair $\langle u_i,\alpha_i,\beta_i\rangle$ having the j th largest u_i, u_i is the order inducing variable and $\left|\alpha_i-\beta_i\right|$ is the disagreement variable claimed by respective distances, λ is a parameter, $\lambda\in(-\infty,+\infty)$.

To attention，if the weighting vector is not normalized, such as $W=\sum_{j=1}^{n}w_j\neq 1$, then, the IFIGOWAD operator is shown as follow:

$$IFIGOWAD\left(\langle u_1,\alpha_1,\beta_1\rangle,...,\langle u_n,\alpha_n,\beta_n\rangle\right)=\left(\frac{1}{W}\sum_{j=1}^{n}w_j d_j^{\lambda}\right)^{1/\lambda} \tag{5}$$

To IFIGOWAD, there are idempotent, bounded, monotonic and commutative attributes which gives the filiation of the operators. Now, it differentiates among the relatives in t W and those in λ.

Note 1. If $\lambda=1$, IFIOWAD operator is shown as follow.

$$f\left(\langle u_1,\alpha_1,\beta_1\rangle,...,\langle u_n,\alpha_n,\beta_n\rangle\right)=\sum_{j=1}^{n}w_j d_j \tag{6}$$

Note 2. If $\lambda=2$, the intuitionistic fuzzy Euclidean ordered weighted averaging distance (IFEOWAD) operator is shown as follow.

$$f\left(\langle u_1,\alpha_1,\beta_1\rangle,...,\langle u_n,\alpha_n,\beta_n\rangle\right)=\left(\sum_{j=1}^{n}w_j d_j^{2}\right)^{1/2} \tag{7}$$

Note 3. If $\lambda=-1$, IFIOWHAD operator is shown as follow.

$$f\left(\langle u_1,\alpha_1,\beta_1\rangle,...,\langle u_n,\alpha_n,\beta_n\rangle\right)=\frac{1}{\sum_{j=1}^{n}\frac{w_j}{d_j}} \tag{8}$$

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The IFIGOWAD is generalized by quasi-arithmetic means, which is named Quasi-IFIOWAD operator. Its advantages include all kinds of special cases which is setup as follow.

Definition 6. A Quasi-IFIOWAD operator of dimension n is a mapping $QIFIOWAD$: $R^n \times \Omega^n \times \Omega^n \to R$ that has an associated weighting vector W with $w_j \in [0,1]$ and $\sum_{j=1}^{n} w_j = 1$ such that:

$$QIFIOWAD\left(\langle u_1, \alpha_1, \beta_1\rangle, ..., \langle u_n, \alpha_n, \beta_n\rangle\right) = g^{-1}\left(\sum_{j=1}^{n} w_j g\left(d_j\right)\right) \tag{9}$$

where d_j is $|\alpha_i - \beta_i|$ value of the QLIOWAD pair $\langle u_i, \alpha_i, \beta_i\rangle$ having the j th largest u_i, u_i is the variable for order inducing and $|\alpha_i - \beta_i|$ is the variable for disagreement represented by individual distances, and g are strictly monotonic and general continuous functions.

Using hybrid averages, the IFIGOWAD can be generalized in further. So that, the intuitionistic fuzzy induced generalized operator using hybrid average distance named IFIGHAD is get to care the emotional probability and the individual attributes of the investor of the investor as shown as follow.

Definition 6. An IFIGHAD operator of dimension n is a mapping $IFIGHAD$: $R^n \times \Omega^n \times \Omega^n \to R$ that has an associated weighting W with $w_j \in [0,1]$ and $\sum_{j=1}^{n} w_j = 1$ such that:

$$IFIGHAD\left(\langle u_1, \alpha_1, \beta_1\rangle, ..., \langle u_n, \alpha_n, \beta_n\rangle\right) = \left(\sum_{j=1}^{n} w_j d_j^{\lambda}\right)^{1/\lambda}$$

where d_j is $\hat{d}_i$ value ($\hat{d}_i = n\omega_i |\alpha_i - \beta_i|$, $i = 1, 2, ..., n$) of the IFIGHAD pair $\langle u_i, \alpha_i, \beta_i\rangle$ having the j-th largest u_i, u_i is the order inducing variable, $\omega = (\omega_1, \omega_2, ..., \omega_n)$ is the weighting vector of the $|\alpha_i - \beta_i|$, with $\omega_i \in [0,1]$ and the sum of the weights is 1, and λ is a parameter such that $\lambda \in (-\infty, +\infty)$.

So that, if $w_i = 1/n$, for all i, the IFIGHAD operator becomes the IFWD, and if $\omega_i = 1/n$, for all i , it becomes the IFIGOWAD operator (Pan Tiejun et al., 2018). Moreover, many other families is discussed according to the theory.

IV. VIRTUAL EXAMPLE

Next, a robotics investment instance is shown using the new method that a manager of robotics foundations wants to setup the portfolio for the investors. After an investigation, the manager has acquired the robotics company reports. Based on the vaguer information, the group of investment experts think about five possible companies $A_i (i = 1, 2, ..., 5)$. By analyzing the

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data, the experts has evaluated according to six attributes: PE (C_1), PS (C_2), Pb (C_3), Month price momentum (C_4), Month transaction amount (C_5) and other aspects (C_6).

By analysing the data, the experts abstract the data and get the results of IFNs, as shown in TABLE I.

TABLE I. Attributes of the decisions making

	G_1	G_2	G_3	G_4	G_5	G_6
A_1	(0.5,0.4)	(0.5,0.3)	(0.2,0.6)	(0.4,0.4)	(0.5,0.4)	(0.3,0.5)
A_2	(0.7,0.3)	(0.7,0.3)	(0.6,0.2)	(0.6,0.2)	(0.7,0.2)	(0.4,0.5)
A_3	(0.5,0.4)	(0.6,0.4)	(0.6,0.2)	(0.5,0.3)	(0.6,0.3)	(0.4,0.4)
A_4	(0.7,0.2)	(0.7,0.2)	(0.4,0.2)	(0.5,0.2)	(0.4,0.4)	(0.6,0.3)
A_5	(0.4,0.3)	(0.5,0.2)	(0.4,0.5)	(0.4,0.6)	(0.3,0.4)	(0.7,0.2)

Corresponding to investor preference, the manager chooses the following appropriate candidate shown in TABLE II.

TABLE II. Choosing Company

	C_1	C_2	C_3	C_4	C_5	C_6
I	(0.8,0.1)	(0.9,0)	(0.8,0.1)	(0.9,0.1)	(0.8,0.1)	(1,0)

For accumulating the data, the decision-making experts compute the relative attributes of the company as shown in TABLE III.

TABLE III. Dependent variables of Decision making

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	17	13	9	12	10	7

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A_2	12	6	24	17	8	30
A_3	16	14	12	10	9	8
A_4	14	17	20	12	16	8
A_5	15	13	11	17	8	19

Based on this data, it is possible to use the IFIGHAD to select a candidate corresponding to the interests of the investor. Suppose that, without loss of generality, $\lambda = 2$, and the weighting vector $W = (0.09, 0.17, 0.24, 0.24, 0.17, 0.09)$, which is derived by the Gaussian distribution based method, and $\omega = (0.12, 0.18, 0.12, 0.26, 0.15, 0.17)$, then we get

$IFIGHAD(A_1, I) = 0.447$, $IFIGHAD(A_2, I) = 0.262$, $IFIGHAD(A_3, I) = 0.336$

$IFIGHAD(A_4, I) = 0.271$, $IFIGHAD(A_5, I) = 0.414$

For this instance, the result shows the distance among the IFNs of the candidate and the prefect company. Because the lowest value in each method is the best result if using distances. So that, all the candidates' rank is given A_i $(i = 1, 2, 3, 4, 5)$

$A_2 \succ A_4 \succ A_3 \succ A_5 \succ A_1$.

V. CASE STUDY

To test the method effect, we use it in the Chinese listed company in stock market at first. MindGo is a quantitative investment platform that provides high-quality and comprehensive quantitative transaction data, speedy portable quantitative back testing experience, extremely simulated simulation trading environment and an open investor exchange community. We make the robots investment portfolio by the multiple factors such as PE, PS, Pb, Month price momentum, Month transaction amount and other aspects. According to the back test from 2014.05.23 to 2018.04.27, the annualized earning of this strategy (red line) is far higher than the Shanghai Composite Index (blue line) at the same time as shown in Fig.1. However, it must also be noted that the maximum retracement of this strategy has reached 48.23% during Stock damage in 2015, which is unbearable to ordinary investors, but it is also worthwhile compared to the huge benefits in the future. Since the U.S. trade representatives announced taxation proposals for China 301 investigations, Chinese robotics-related stocks are in a downward trend. In fact, According to the data of China Machine Tool Industry Association, in 2018, China's consumption of metal cutting machine tools was US $18.11 billion. Among the top 10 listed companies with the highest annual income of metal cutting machine tools, the total revenue of the machine tool business accounted for only 10.39%, and the market share of Shenyang

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Machine Tool (000410-cn), which had the largest share, was only 3.56%. Kunming Machine Tool ranked second has been delisted, and Shenyang machine tool has also come to the brink of delisting. From a cyclical point of view, the delisting of Kunming Machine Tool, an industry leader, means that domestic machine tools are difficult to survive in the low-end field, and enterprises with high-end CNC machine tools as their core will rise, and the low- and medium-end production capacity will be gradually cleared. Industrial upgrading will play a positive role. It can be seen that although the proportion of Chinese domestic robot companies in the advanced robot business is low, but the overall situation is slowly increasing. At present, the localization rate of high-performance and high-precision CNC machine tools in China is not high. According to the data of the Prospective Industry Research Institute, in recent years it has been only 6%, and high-end CNC machine tools mainly rely on imports. According to the statistics of the General Administration of Customs, the number of imported machine tools in China increased to 14,420 in 2018, mainly in mid-to-high-end machining centers, with a total import of US $ 3.379 billion and an average price of US $ 230,300, which is much higher than the average price of the domestic machine tool market. From this perspective, there is still much room for the development of domestic substitution.

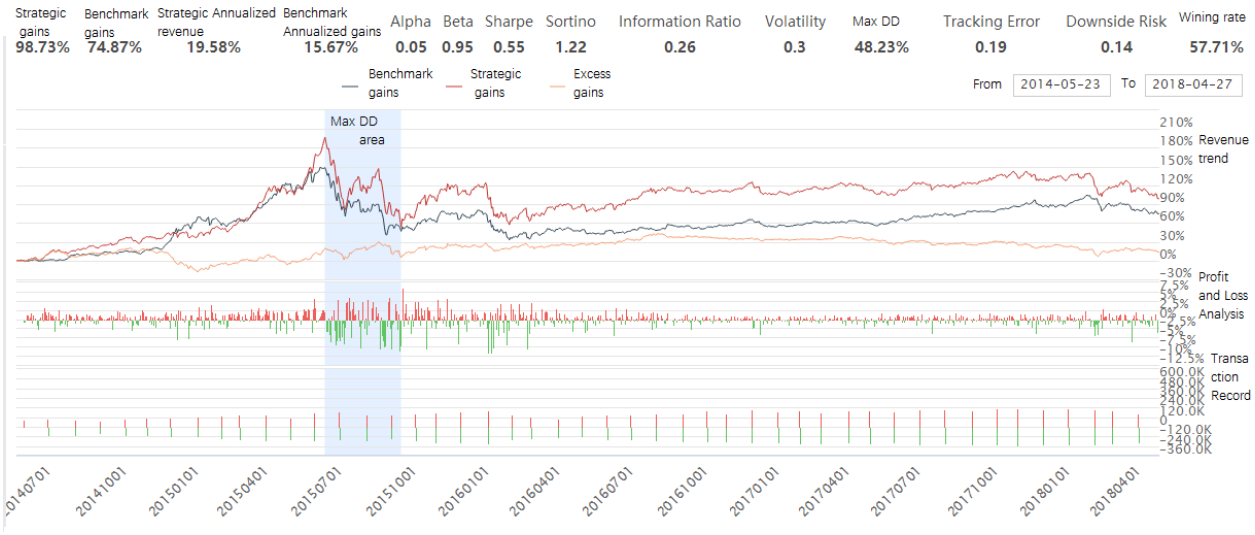

Fig 1: The back test of Multi-factor strategy of robotics using weighted induced method

With the development of China's economy and the prevalence of global investment, investment in strategic emerging industries, especially the robotics industry, has gradually become a new demand for wealth management of the Chinese people. For this reason, China's brokerage industry has gradually begun to transform and upgrade from a brokerage business to a national strategic investment business, providing better investment targets and investment advisory services for robot industry companies. In order to lower the threshold for investment in

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the robotics industry, the banking industry has also begun to establish wealth management subsidiaries at the end of 2018. As of November 2019, the wealth management subsidiaries of chines banks have opened and started to issue investment in the robotics industry. How to realize the asset allocation and asset management requirements of the robotics industry through uncertainty decision analysis is a problem that financial institutions urgently need to solve. Only through the implementation of big data technology and artificial intelligence technology can this contradiction between supply and demand be effectively resolved. In addition, if wealth management subsidiaries want to expand the types of wealth management products to meet the strategic investment and wealth management needs of the robotics industry, they need to carry out multi-market robotics industry quantitative investment research, strategy development and asset allocation to match the risk appetite of different customers and group decision-making investment The research team will be the direct user of this method.

With the development of the private equity fund industry, the current capital management scale of private equity funds has exceeded that of public equity funds. According to statistics from the China Securities Investment Fund Industry Association, as of the end of June 2019, there were 8,875 private equity investment fund managers, 38,538 managed funds, and 2.33 trillion yuan of funds under management; 135 public equity funds were managed by public equity funds. The total number of funds under management is 5547, and the net asset value of funds under management is 1.07 trillion yuan. The current private equity fund management scale shows a significant head effect and private equity funds focusing on quantitative investment have great advantages in management level and management scale. Constrained by high-tech thresholds and limited human resources, and the lack of effective investment and research tools, the survival of most private equity funds is worrying. In addition, the excessive concentration of funds may bring about the convergence of strategies and easily lead to systemic risks in the market. At the same time, due to the limited range of optional managers, it is not conducive to the development of my country's FOF funds. In the face of increasingly fierce competition in the market, public funds also need to use fuzzy algorithm group decision-making technology to conduct strategic research and development and reduce costs and increase efficiency.

To sum up, the current market is in urgent need of a quantitative investment platform for uncertain investment, so that financial institutions such as brokers and banks can use the platform to promote research on group decision-making investment and support personalized robo-advisor business And the upgrade of quantitative investment asset management business, this method can lower the technical threshold of investment advisory experts, and support ordinary strategy developers in the fund industry to change their staff. They can use fuzzy decision-making methods to assist quantitative investment at a low threshold, and reduce investment research personnel’s fuzzy algorithm. These cases is the best scenario for the application of this method.

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VI. CONCLUSION

In general, we proposed a Multi-factor strategy of robotics investment using a weighted induced model in the uncertain environment. At first, the IF induced aggregation distance operator, named the IFIGOWAD operator is proposed. It generalizes the IOWA operator that uses distance measure, intuitionistic fuzzy information and generalized means. It is shown that this operator covers a kind of IF special cases including the IFGMD, the IFOWD and the IFOWAD operator. In the further, the IFIGHAD operator is present by using the hybrid aggregation. The main advantage of this operator is to deal IF distance measures based on WA and OWA operator. We have also studied the application of the developed operators in robotics investment under the uncertain international situation. The revenue shows that our portfolio strategy is practical, which provide a more robust formulation for the actual problems. In our next research, we would like to develop the application of this method in other domains.

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