International Journal of Control and Automation
Vol. 8, No. 2 (2015), pp. 125-130
http://dx.doi.org/10.14257/ijca.2015.8.2.13

Mechanical Lifting Process of Liquid Steel Metallurgy Collision System

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Abstract

In the process of metallurgy steel mechanical lifting, lifting path is not planned in advance. Under the different path of lifting, lifting machinery and it's easy to have a collision. The use of traditional algorithm for metallurgical molten steel mechanical lifting, it is necessary to preset a complete mechanical lifting path to achieve mechanical lifting process of collision, without fully considering the randomness of lifting path random effects. In order to avoid the disadvantages of the traditional algorithm, this paper puts forward a kind of coordination control algorithm of the collision in the process of metallurgy steel mechanical lifting system. Rough set neural network model is established and the metallurgical molten steel mechanical lifting collision to deal with the noise signal, thereby to metallurgy steel mechanical collision operation to provide accurate basis. Use of coordinated control algorithm, can realize metallurgy steel mechanical lifting collision. The experimental results show that the algorithm presented in this paper for metallurgical molten steel mechanical lifting process of collision can reduce the collision rate of mechanical lifting, thus ensuring the safe operation of the machinery.

***Keywords**: Metallurgical molten steel, Mechanical lifting, Collision, Lifting the path*

1. Introduction

With the industrial development, people have more requirements on metallurgical products [1]. In the process of metallurgical production, liquid steel is lifted to the destination by mechanical lifting equipment [2]. Sometimes, it is asked to lift a large amount of liquid steel in a relatively small space [3]. This may cause collision between lifting machineries. Thus, the mechanical lifting process of liquid steel metallurgy has attracted wide attention of many researchers and experts [4].

At present, dominant methods of mechanical lifting process of liquid steel metallurgy include path planning based on natural semantic conversion algorithm, path planning based on neutral network algorithm and path planning based on ant colony algorithm [5-7].The most common one is the path planning of mechanical lifting process of liquid steel metallurgy based on natural semantic conversion algorithm [8]. Boasting a bright prospect, it has become a focus of many researches [9]. Path planning of mechanical lifting process of liquid steel metallurgy is the core of metallurgy research. Traditional algorithm fails to propose reasonable design of the path and increases the change of collision as a result [10].

This paper proposes a new collision control system based on coordination control algorithm by establishing rough set neural network model to deal with the noise signal so that it can provide accurate basis for the collision control of the mechanical lifting process of liquid steel metallurgy. Through this coordination control algorithm, it is able to avoid collision in the mechanical lifting process of liquid steel metallurgy. Experiment results show that this algorithm outperforms many other algorithms in reducing collision.

ISSN: 2005-4297 IJCA

2. Planning Method of Traditional Mechanical Lifting Path

The natural semantic conversion algorithm enables the path characteristics to transform and makes the optimal path stand out. As the path information is of high randomness, it is necessary to curb the selection characteristics of the path. Details are as follows:

(1) Through data analysis of mechanical lifting process of liquid steel metallurgy, it is possible to get the path selection variables and the characteristics of the path that are representative. These representative characteristics should account for 80% of total characteristics and the rest should be overlooked.

(2) The correlation of path characteristics is acquired by calculation. We will kick off the redundant data. The calculation is expressed as:

$$t = \frac{\sum_{k=1}^{q}(Z_k - \overline{Z}) - (A_k - \overline{A})}{\sqrt{\sum_{k=1}^{q}(Z_k - \overline{Z})\sum_{k=1}^{q} A_k - \overline{A}}} \tag{1}$$

If the correlation parameter is above 0.8, then it is necessary to group the characteristics and delete unnecessary data. Subject all path characteristics to importance analysis and normalization. The normalization calculation is expressed as:

$$Z' = (Z - \overline{Z})/U,$$
$$U = \sqrt{\frac{\sum_{k=1}^{q}(Z_k - \overline{Z})^2}{q-1}} \quad . \tag{2}$$

Thus, all path characteristics fall into the interval $\left[\overline{Z} - 3U, \overline{Z} + 3U\right]$. Delete the data out of the interval.

Path characteristics of mechanical lifting process of liquid steel metallurgy can be expressed by ***M(z)***. According to time domain, path characteristics of different time can be expressed by:

$$M(z,v) = \chi M(z,v-1) + \delta M(z,v) \tag{3}$$

In the expression, $\chi + \delta = 1$ and χ refers to the efficiency of natural semantic transformation. Then, reasonable path can be selected based on the following expression:

$$U = \frac{\sum_{k=1}^{Q} M_k(V) \times N_k(V)}{\sqrt{\sum_{k-1}^{Q} M_k{}^2(V) \cdot \sum_{k-1}^{Q} M_k{}^2(V)}} \tag{4}$$

As is described above, path planning of liquid steel metallurgy in the mechanical lifting process is carried out according to path characteristics and through natural semantic transformation. It avoids the disadvantage of the traditional algorithm which fails to design reasonable paths and increases the chance of collision.

3. Anti-collision Method for Mechanical Lifting Process of Liquid Steel Metallurgy

Collision control of mechanical lifting process of liquid steel metallurgy is a focus in the research. Traditional way fails to design a reasonable path and increases the chance of collision. Therefore, this paper proposes an anti-collision method of mechanical lifting process of liquid steel metallurgy.

3.1 De-noising of Metallurgical Molten Steel Machine Collision Signals

The collision signal of mechanical lifting process of liquid steel metallurgy is easily influenced by the environment and generates much noise. Therefore, we need to deal with the noise and get rid of its influence. Rough neural network is thus introduced.

According to Fourier transformation algorithm, the collision signal of liquid steel metallurgy is detected as:

$$H(k,y)=\int_{-\infty}^{+\infty}[h(w)i'(w-v)]f^{-ly}dw \tag{5}$$

In the expression, ***h(w)*** is used to describe the collision signal, ***i(w-v)*** is the window function.

Rough neural network state parameter is calculated by the following expression:

$$H(z)=G[f^T f]=G[(v-q)^2] \tag{6}$$

where ***H(z)*** is the performance parameter of rough neural network, *v* is the expectation output of rough neural network, ***q*** is the actual output. The parameters can be updated by the following expression.

$$\hat{H}(z)=(v-q)^T(v-q)=f^T f \tag{7}$$

The weight of the collision is represented by $\boldsymbol{y_{kj}}$. Corresponding displacement parameter is referred to as $\boldsymbol{t_l}$. Extended parameter is described as $\boldsymbol{c_l}$. Get the derivation and acquire the transmission error of the collision signal:

$$\partial H/\partial y_m=-\sum_{k=1}^{Q}\{h(q)[\cos(2\pi(q-\omega_k)/c_k)-\cos(\pi(q-\omega_k)/c_k)]/[\pi(q-\omega_k)/c_k]\} \tag{8}$$

The adverse transmission parameter for the collision signal is calculated by the following expressions:

$$\begin{cases} u_2=-\hat{H}_2(v-q)=-(v-q) \\ u_1=\hat{H}_1(Y_2)^T u_2 \end{cases} \tag{9}$$

In the expression, $\boldsymbol{u_1}$ is to describe the adverse transmission parameter in the output layer. $\boldsymbol{u_2}$ is to describe the adverse transmission parameter in the hidden layer. $\boldsymbol{Y_2}$ is the derivation result of rough neural network parameter. Establish the rough neural network model based on the following expression:

$$R_{p(m+1)}=R_{pm}-\chi u_p \tag{10}$$

In the expression, $R_{p(m+1)}$ is used to describe the updated result of rough set in layer p. χ is the training rate of the liquid steel metallurgy in the mechanical lifting process. u_p refers to the sensitivity of signal adverse transmission.

Noise in the collision signal can be eliminated based on the abovementioned method. The signal quality is improved as a result. It provides a basis for the collision control of liquid steel metallurgy in mechanical lifting process.

3.2 Achieving Anti-collision for Mechanical Lifting Process of Liquid Steel Metallurgy

Collision is easy to occur in mechanical lifting process of liquid steel metallurgy. Therefore, coordination control algorithm is introduced to collision control so as to prevent the accident from happening.

As a core issue in the field of metallurgy, how to avoid collision in the mechanical lifting process of liquid steel metallurgy and maintain the efficiency of lifting is a concern of artificial intelligence.

Collision can be judged based on the distance between metallurgical molten steel machineries. The distance of geometric centers of two machineries is calculated by the following expression:

$$\|r_2 - r_1\| = \sqrt{(r_2 y - r_1 y)^2 + (r_2 z - r_1 z)^2 + (r_2 a - r_1 a)^2} \quad (11)$$

The shortest distance between any two mechanical lifting paths is calculated by the following expression:

$$f(m_C^D, m_D^E) = \min\{\|z - a\| : z \in m_C^E, a \in_D^E\} \quad (12)$$

As a result, we can judge whether the collision will occur. All machineries are complicated geometries that are regarded as consisting of many sub-elements.

The collision radius is calculated by the following expression:

$$m_r = \{z_r : \|z_r - z\| \le t_r, a \in m_r^E\}, t_r \ge 0, r = B, C \quad (13)$$

The distance between metallurgical molten steel lifting machineries is calculated as:

$$f(m_C, m_D) = f(m_C^E, m_D^E) - t_C - t_D \quad (14)$$

If the distance between two machineries is smaller than the collision radius, it is necessary to change the path. Otherwise, machineries can keep moving as there will be no collision.

The rough neural network model is established to deal with the noise in the signal, which provides an accurate basis for the collision control of liquid steel metallurgy in the mechanical lifting process. The coordination control algorithm is able to prevent the collision.

4. Experimental Results and Analysis

It is necessary to conduct an experiment to prove the efficacy of the algorithm presented by this paper. Matlab is introduced to do the simulation. Set the starting points of the metallurgical molten steel lifting machineries as (1, 7) and (5, 8). Their corresponding destination points are (2, 4) and (7, 2).

Traditional algorithm and the algorithm proposed by this paper are subject to the experiment. Those paths that are acquired are shown in Figure 1.

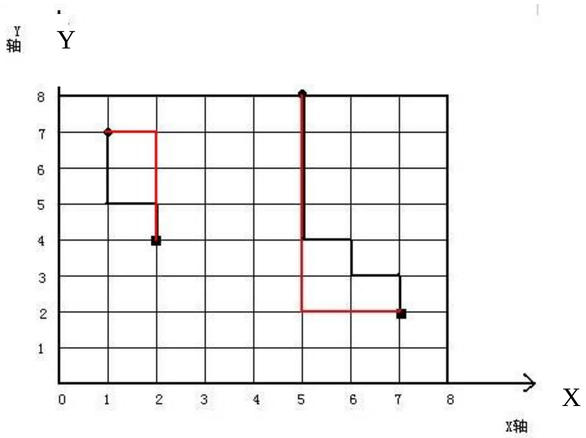

Figure 1. Lifting Paths of Different Algorithms

As is shown in Figure 1, the path by traditional algorithm can be expressed by [17,27,26,25,24] and [58,57,56,55,54,53,52,62,72] while that of the newly proposed algorithm can be expressed by [17,16,15,25,24] and [58,57,56,55,54,64,63,73,72].

Change the starting point and the destination point in the same space to see the algorithm's adaptation to the environment. Repeat the experiment under new points and describe the result by the Figure 2:

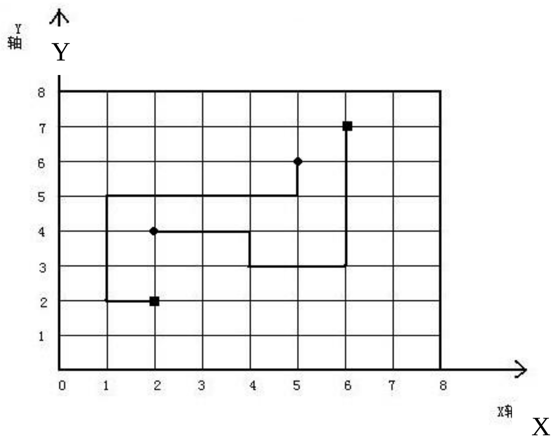

Figure 2. Anti-collision Result of the Algorithm used in this Paper

The Figure above shows the operation path of the machinery. The collision is able to be avoided. To show the advantage of the proposed algorithm, both traditional algorithm and the new one are subject to 10 times of experiment. The results are shown in Figure 3.

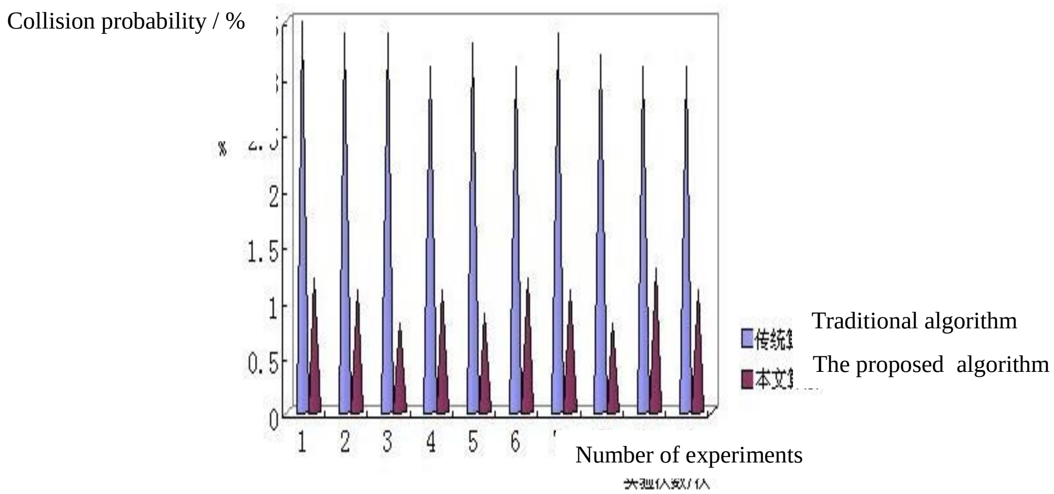

Figure 3. Comparison of the Different Algorithms

Analyze the experiment results, as is shown in Table 1.

Table 1. Experimental Statistics for Different Algorithms

Number of experiments (No.)	Probability of collision based on traditional algorithm (%)	Probability of collision based on the algorithm of this research (%)
1	3.5	1.2
2	3.4	1.1
3	3.4	0.8
4	3.1	1.1
5	3.3	0.9
6	3.1	1.2
7	3.4	1.1
8	3.2	0.8
9	3.1	1.3
10	3.1	1.1

According to Table 1, the proposed algorithm is proved to be able to design reasonable lifting paths and avoid the collision of liquid steel metallurgy in the mechanical lifting process.

5. Conclusion

This paper proposes a collision control system of liquid steel metallurgy in the mechanical lifting process based on coordination control algorithm. It establishes the rough neural network model and deals with the noise in the collision signal, which serves as a basis for the collision control.

This coordination control algorithm can achieve the collision control of liquid steel metallurgy in the mechanical lifting process. Experiment results show that this algorithm is able to design reasonable paths for the lifting and avoids the collision. As a result, the collision control system is proved to be feasible and meets the demand of production.

ACKNOWLEDGEMENTS

This work is supported by Natural Science Foundation of China (51465045) and Scientific Research Foundation of Dongguan Polytechinic (2014a03).

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