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Research on Mechanized Construction Technology of Transmission Line Engineering in Gobi Desert Environment

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SUMMARY: *In modern society, the construction of power transmission and transformation engineering is an important foundation for promoting industrial development and improving the convenience of life, and the transmission line as the key chain of power transmission. This paper breaks down and disassembles the mechanized construction technology of transmission line project in Gobi desert environment from four aspects: apparatus entry, mechanical work, progress coordination and cost control. The improved YOLOv3 detection algorithm is proposed for the real-time detection of the entry and work of the transmission line project equipment in the Gobi desert environment to ensure the safety of the construction site. For the two aspects of schedule coordination and cost control, the constructed schedule-cost-quality balanced optimization model of transmission line project is solved by using the improved ant colony algorithm, and the entropy value-TOPSIS method is used to make decisions on the scheme. The results show that the improved YOLOv3 detection algorithm significantly improves the detection precision of engineering vehicles, and the accuracy rate can reach 88.9% and the recall rate reaches 82.8%; the improved ant colony algorithm is very suitable for multi-objective duration-cost-quality optimization, and the optimal set of solutions obtained can provide a powerful support for decision-making of the managers of transmission line construction projects.*

KEYWORDS: *deep learning; target detection; ant colony algorithm; entropy value method; mechanized construction of transmission line*

1 Introduction

Transmission lines are an important part of the electric power network system, which undertakes important power supply and distribution tasks [1]. The Gobi desert region, with its abundant sunshine and stable or seasonally significant wind, is often an ideal area for photovoltaic, wind power and related transmission and distribution projects. However, temperature extremes, frequent dust and sand activities, scarce rainfall and restricted water sources are factors that seriously hinder the effective construction of transmission line projects [2, 3]. This is due to the fact that almost all operations in traditional transmission line construction are done manually, which simply cannot be carried out effectively in the Gobi desert environment. With the progress of technology, mechanized construction replaces the traditional human construction, which promotes the realization of economic and social benefits of transmission line projects in the Gobi desert [4, 5].

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The advantages of the application of mechanized construction technology for transmission line projects in the Gobi desert environment mainly include reducing the burden of labor, putting the construction cost, and guaranteeing construction safety [6]. Under the mechanized construction operation mode, almost all the transmission line construction tasks can be realized by mechanized operation, and this mechanical alternative to human construction reduces the human input in the construction process, improves the overall efficiency of construction, and saves the construction cost [7-9]. For example, in the process of line tensioning, the traditional manual tensioning mode, the human input is more, and each person must maintain its power state, while the mechanized construction manpower input is smaller, mechanical equipment can achieve ideal construction results [10-12]. In addition, the application of the whole process of mechanized construction technology greatly reduces the overall cost of construction, mainly due to its mechanized construction of higher efficiency, saving construction time, and mechanized construction of higher quality, reducing rework, misuse and other phenomena, effectively avoiding the traditional manpower construction errors, improving the overall quality of transmission line construction, reducing the maintenance costs in the later stage [13-16]. In terms of safety and security, under the mechanized construction technology, manpower can avoid a series of dangerous operation links, relying only on machinery to complete the corresponding construction process, which reduces the occurrence of construction safety accidents to a certain extent, and protects the personal and ecological safety of construction [17-20].

The development and application of mechanized construction technology, so that the construction of transmission line project to get rid of the traditional by the entire manual construction of low efficiency, poor quality, environmental damage and other issues. Literature [21] describes the significance of mechanized construction of transmission lines, which is an important way to continuously improve the construction capacity of power grid projects, improve the level of construction technology, and promote the transformation and upgrading of construction enterprises. Literature [22] analyzes the transmission line construction technology in complex environments, especially the application of overhead transmission lines, and reveals the utilization of overhead transmission lines through testing, which effectively improves the carrying capacity of transmission lines. Literature [23] assessed and analyzed the environmental impacts of transmission and substation projects and proposed countermeasures for rapid ecological restoration of mechanized construction in grid construction projects, emphasizing that mechanized construction provides technical support for ecological restoration in the area of grid construction projects. Literature [24] analyzed the limitations of traditional foundation types in mechanized construction of UHV transmission line projects, summarized the boundary conditions applicable to traditional foundations, and selected new types of foundations, such as micropile foundations, to adapt to the needs of mechanized construction. Literature [25] describes the whole process of mechanized construction of transmission lines and details the design points in terms of material transportation, tower installation, and ecological environmental protection, revealing that mechanized construction effectively improves the effectiveness and efficiency of power grid construction. Literature [26] points out that transmission line construction is an important part of power grid engineering construction, and improving its mechanization rate has many advantages, such as high quality, high economic benefits and high social benefits. Literature [27] points out that power grid engineering puts forward higher requirements for the digital level of geographic information, and based on the characteristics of transmission line engineering, it is proposed to apply 3D technology to the mechanization of transmission line engineering, and the results show that the application of 3D technology can promote the transformation of the construction management mode and improve the construction efficiency.

The research revolves around the intelligent technology of mechanized construction of transmission lines, which is analyzed from the aspects of construction vehicle detection and multi-objective management of mechanized construction. For the YOLOv3 algorithm, DIoU is used to optimize the loss function, which makes the bounding box accelerate close to the real box; k-means++ algorithm is used to replace the k-means algorithm, and an improved YOLOv3 algorithm is proposed to improve the brightness of the data pictures and optimize the data set, so as to improve the accuracy of the detection model. On the basis of analyzing the relationship between duration-cost-quality during the infrastructure period of transmission line construction project, the duration-cost-quality balanced optimization model is constructed, and the improved multiple swarm ant colony cooperative algorithm is used to simulate the simulation in combination with the engineering examples to obtain the duration, cost, quality of the Pareto optimal solution, and designed the entropy value-TOPSIS algorithm to make decisions on the program.

2 Mechanized construction based on BIM technology

2.1 Instrument entry

Most of the transmission line projects are located in fields and mountains far away from populated areas, and transportation conditions vary from tower to tower in the project. With the improvement of environmental protection requirements, the previous practice of building longer lines directly to the tower locations from locations with ideal transportation conditions is no longer in line with the requirements of sustainable development. At present, in the planning stage of apparatus approach, it takes more and more time for the construction personnel to familiarize themselves with the traffic conditions near the towers as well as the policy requirements of different places, and it takes longer time to determine the final approach road plan after docking with the departments at various levels.

2.2 Mechanical operations

With the restructuring of the construction team's personnel structure, most of the front-line jobs are for newcomers, whose lack of experience in transmission line foundations and tower assemblies, and conductor-ground wire erection has caused an increase in the time cost of explaining the safety points and difficulties before the construction of the various phases, and the time cost for selecting and operating the equipment, and an increase in the number of on-site reworks and later reworks, which has a greater impact on the engineering milestone plan and project settlements.

2.3 Progress integration

At present, the degree of marketization of the construction of electric power engineering projects is not as good as that of other construction projects. Transmission line projects of power grid companies are still constructed by transmission and substation engineering companies belonging to provincial power companies, and the construction units still control the progress of the project by traditional methods such as Gantt charts, crosswalk charts and milestone plans. Transmission line project due to the construction of more units, different construction units using different methods, its various stages of making plans for the staff still rely on experience to make rough estimates, which leads to a number of progress control closure often appear "broken network" problem. In addition, when unexpected problems and design issues are encountered, there will be slowdowns and delays in work, making it impossible to effectively mobilize personnel and equipment across the board.

2.4 Cost control

Each participating unit and subcontracting team in the transmission line project adopts various methods for cost management and control. At present, the construction drawing budget, the construction of each individual settlement, design changes and visas, project summary calculation and other stages need costing personnel to calculate the amount of work and the list. The cost personnel have different personal business level and working habits, and do not grasp the actual construction situation in a timely and comprehensive manner, which has a greater impact on the cost control of cost investment, personnel and equipment allocation, and the arrangement of material purchasing reserve.

3 Transmission Line Construction Vehicle Detection Based on Improved YOLOv3 Algorithm

The accidents of transmission line destruction caused by the brutal construction of engineering vehicles are frequent. Traditional transmission line protection methods such as manual inspection and real-time monitoring cannot detect hidden dangers in time, and it is easy to miss the inspection phenomenon. In order to solve the shortcomings of the traditional way, this paper proposes an engineering vehicle detection algorithm for transmission line scenarios by combining deep learning technology.

3.1 YOLOv3 detection algorithm

3.1.1 YOLOv3 overall network architecture

YOLOv3 is a target detection algorithm that effectively maintains a balance between detection speed and accuracy. It is able to predict all the bounding boxes as well as the category probabilities in the whole image at once. The algorithm consists of two parts: a feature extraction network and a detection network. The feature extraction network chosen is Darknet-53, which is composed by a series of residual modules. The detection network, on the other hand, draws on the idea of feature pyramid (FPN), which can make multi-scale prediction of the input image and output the results, which greatly improves the network's ability to detect and recognize targets at different scales compared with previous algorithms.The network structure of YOLOv3 is shown in Fig. 1.

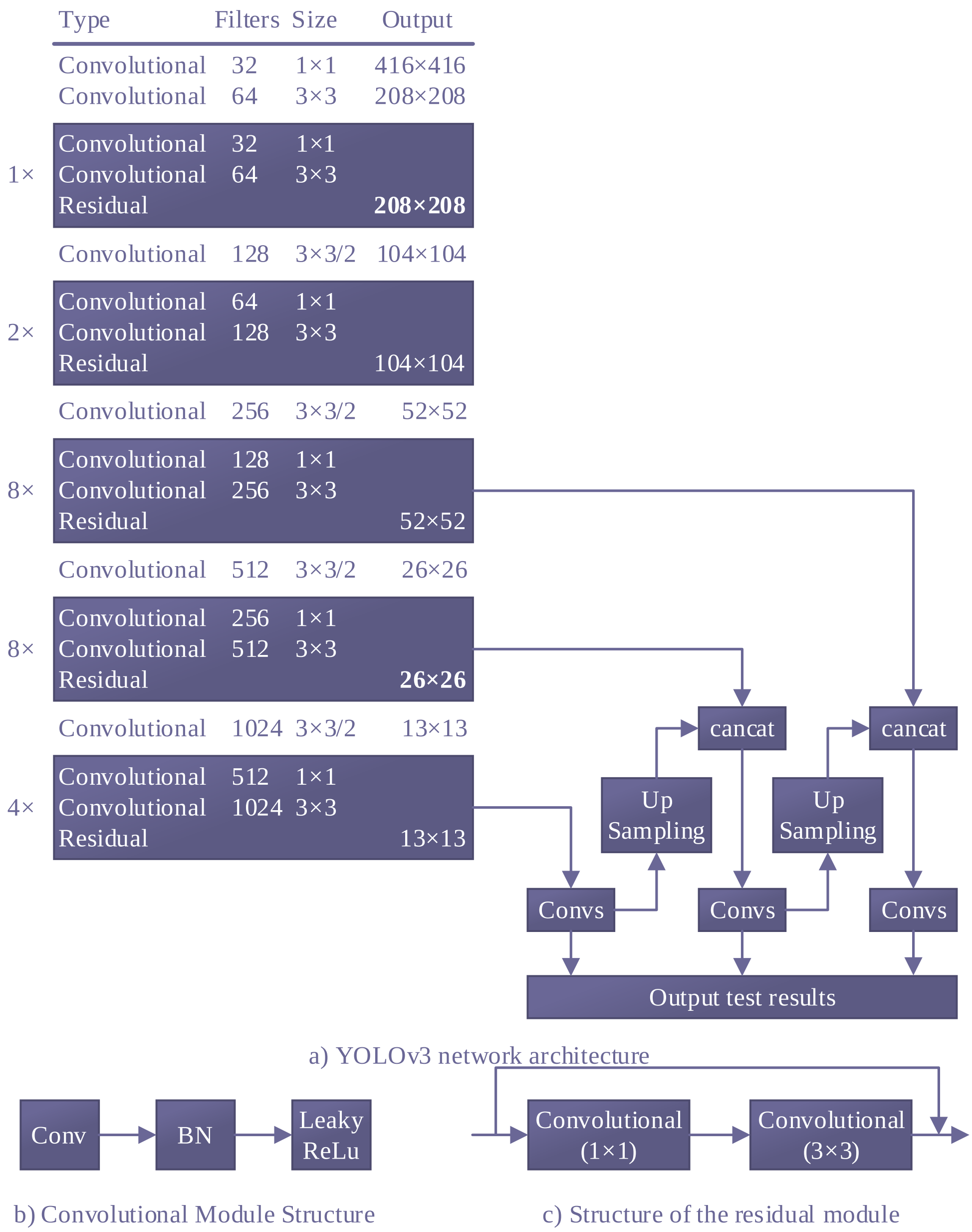

Figure 1: YOLOv3 network diagram

3.1.2 Boundary box projections

YOLOv3 uses k-means clustering algorithm to get 9 prior frames with different sizes, these prior frames will be equally divided into 3 groups according to their sizes: large, medium, and small, and after that, they will be assigned according to the sizes of the sensory fields of the 3 feature maps, for example, the largest size of the 3 prior frames will be assigned to the feature map of 13×13. Then the bounding box is predicted by these a priori boxes. The process of predicting the bounding box is shown in Fig. 2.

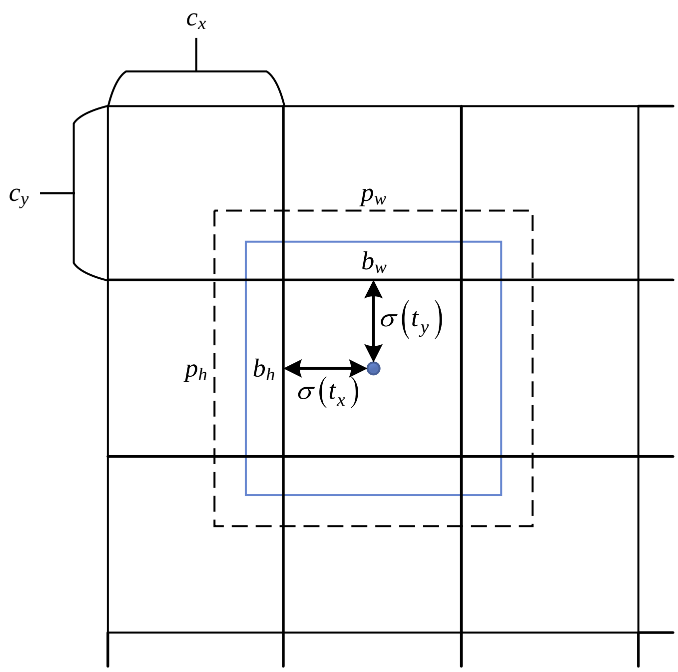

Figure 2: Prediction of bounding box positions

The t_x and t_y in the figure are the coordinate offset values predicted by the network, while t_w and t_h are the width-to-height scaling ratios predicted by the network, respectively, and all four values are the parameters obtained by the network undergoing actual training. The coordinates of the upper left corner of the cell are $\left(c_x, c_y\right)$, while p_w and p_h are the width and height of the prior frame. With these values the predicted coordinates of the center of the bounding box $\left(b_x, b_y\right)$ as well as the width b_w and the height b_h of the bounding box can be found. The prediction formula for the bounding box is shown in equation (1):

$$\begin{cases} b_x = \sigma\left(t_x\right) + c_x \\ b_y = \sigma\left(t_y\right) + c_y \\ b_w = p_w e^{t_w} \\ b_h = p_h e^{t_h} \end{cases} \tag{1}$$

The $\sigma\left(t_x\right)$ and $\sigma\left(t_y\right)$ in the equation are normalized by the sigmoid function for the values t_x and t_y, making their value domain in the interval from 0 to 1, which can speed up the convergence speed when the model is trained. And it can also avoid the problem that the center of the bounding box is not in the cell due to too much offset of the center coordinates.

3.1.3 Loss function

Loss function has an important position in deep learning. It can well reflect the degree of agreement between the predicted value and the real value of the model. The smaller the loss function is, the closer the predicted value of the model will be to the true value.The loss function in YOLOv3 consists of the bounding box regression loss $loss_{reg}$, the confidence loss $loss_{conf}$, and the categorization loss $loss_{class}$ These three components are composed. The formula is shown in equation (2):

$$loss = loss_{reg} + loss_{conf} + loss_{class} \tag{2}$$

where the equation for the bounding box regression loss is shown in equation (3):

$$\begin{aligned} loss_{reg} &= \lambda_{coord} \sum_{i=0}^{s^2} \sum_{j=0}^{B} I_{ij}^{obj} \left[\left(x_i^j - \hat{x}_i^j \right)^2 + \left(y_i^j - \hat{y}_i^j \right)^2 \right] \\ &+ \lambda_{coord} \sum_{i=0}^{s^2} \sum_{j=0}^{B} I_{ij}^{obj} \left[\left(\sqrt{w_i^j} - \sqrt{\hat{w}_i^j} \right)^2 + \left(\sqrt{h_i^j} - \sqrt{\hat{h}_i^j} \right)^2 \right] \end{aligned} \tag{3}$$

Eq. represents when the jth a priori frame in the ith grid is responsible for the detection of the object, the loss values of the center coordinates and width and height are calculated by comparing the bounding box produced by the a priori frame with the real frame.

The loss of confidence formula is shown in equation (4):

$$\begin{aligned} loss_{conf} &= -\sum_{i=0}^{S^2} \sum_{j=0}^{B} I_{ij}^{obj} \left[\hat{C}_i^j \log\left(C_i^j\right) + \left(1 - \hat{C}_i^j\right) \log\left(1 - C_i^j\right) \right] \\ &- \lambda_{noobj} \sum_{i=0}^{S^2} \sum_{j=0}^{B} I_{ij}^{noobj} \left[\hat{C}_i^j \log\left(C_i^j\right) + \left(1 - \hat{C}_i^j\right) \log\left(1 - C_i^j\right) \right] \end{aligned} \tag{4}$$

The formula for classification loss is shown in equation (5):

$$loss_{class} = -\sum_{i=0}^{s^2} I_{ij}^{obj} \sum_{c \in classes} \left[\hat{P}_i^j(\mathrm{c}) \log\left(P_i^j(c)\right) + \left(1 - \hat{P}_i^j(c)\right) \log\left(1 - P_i^j(c)\right) \right] \tag{5}$$

3.2 YOLOv3 algorithm improvement

Although the YOLOv3 algorithm has good detection speed and accuracy, after testing, it is found that the algorithm is not ideal for the detection of engineering vehicles under the environment of transmission lines, and small targets are often missed in images with complex environments, and there is also the problem of too large a change in detection accuracy after the target scale transformation. Therefore, the network structure of YOLOv3 should be improved to improve the extraction of engineering vehicle features and enhance the detection performance of engineering vehicles.

3.2.1 A priori frame acquisition based on k-means++

The general k-means algorithm uses the Euclidean distance, with two points with coordinates (x_1, y_1) and (x_2, y_2), then their Euclidean distance is computed as shown in Equation (6):

$$distance = \sqrt{\left(x_2 - x_1\right)^2 + \left(y_2 - y_1\right)^2} \tag{6}$$

However, in YOLOv3, if the Euclidean distance is used, the results obtained after clustering are mainly affected by the size of the bounding box, but when using the bounding box, its performance is determined by the intersection ratio between the predicted box and the real box, so the value of the intersection ratio is chosen as a criterion for the determination, and the formula is shown in equation (7):

$$distance = 1 - IoU(box, centroid) \tag{7}$$

The centroid in the equation is the real box selected as the center of clustering and box is the other real box.IoU (Intersection over Union) is the intersection over union ratio of two real boxes, its value is the area of the intersection part of two borders divided by the area of the concatenation part of two borders.

k-means has the advantage of being simple to understand and easy to implement, but it also has drawbacks. The choice of initial points often has an important impact on the clustering results, due to its initial point selection is completely random, it is very easy to fall into the local optimal rather than the global optimal state during training. The k-means++ algorithm is chosen to cluster the real boxes in the dataset to obtain a priori boxes that meet the requirements. k-means++ algorithm in which only the first center is randomly determined, the rest of the centers are selected to be the farthest point from all the current centers.

3.2.2 DIoU-based positional loss improvement

In this paper, DIoU (Distance-IoU) is introduced into the position loss function, which takes into account more overlap area and centroid distance than the original IoU, and by introducing a penalty term to bring the distance between two frames closer, even if there is no intersection generated between the two frames, it is still possible to find the moving direction for the predicted frames.The formula of DIoU is shown in equation (8):

$$DIoU = IoU - \frac{\rho^2\left(b, b^{gt}\right)}{c^2} \tag{8}$$

The b and b^{gt} in Eq. represent the centroids of the prediction frame and the true frame, $\rho(\cdot)$ is used to compute the Euclidean distance between these two points, and c is the diagonal length of the smallest enclosing frame that will cover this frame.

The formula for DIoU as the positional loss part of YOLOv3 is shown in Eq. (9):

$$L_{DIoU} = 1 - IoU + \frac{\rho^2\left(b, b^{gt}\right)}{c^2} \tag{9}$$

3.3 Engineering Vehicle Inspection Test Results and Analysis

3.3.1 Test platforms and data sets

The test platform and parameters are configured as follows: operating system Centos7, CPU Intel (R) Xeon (R) Glod5118 CPU@2.3GHz, GPU GeForce RTX2080T, 24G of video memory, 128G of memory, framework Darknet53, programming environment Python.

The original drawings of the transmission line construction project vehicle data were provided by a company, totaling 11,366, including 4,809 pictures of cranes, 4,893 pictures of excavators, 640 pictures of forklifts, 565 pictures of concrete pouring trucks, 281 pictures of concrete mixers, and 158 pictures of road rollers.

Due to the influence of time and climate, there will be cases of low light in the evening or cloudy days, so it is necessary to preprocess all the pictures to improve the brightness of the pictures. First of all, the input pictures are grayed out, by setting the gray threshold to specify 0 to 39 as dark pixel points, and counting the number of dark pixels, the statistics are shown in Figure 3. According to the actual situation, P is set to be more than 22%, which indicates that the picture is dark. Finally, the pictures with P higher than 22% are filtered out.

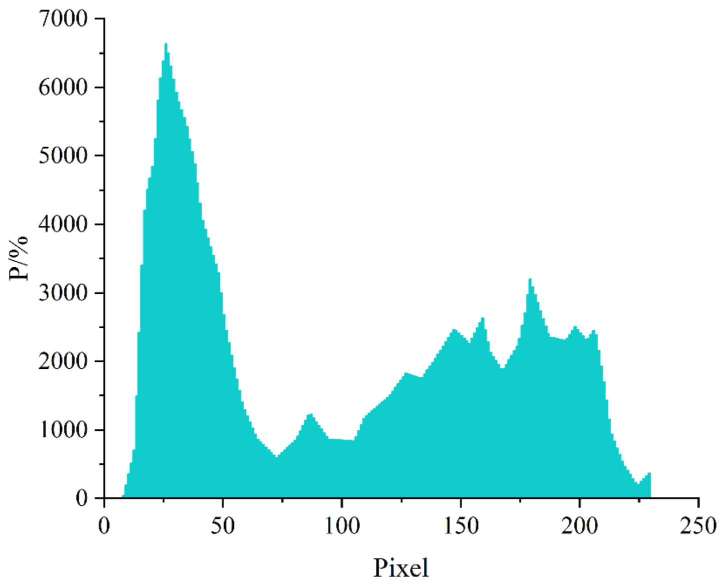

Figure 3: Pixel count chart

3.3.2 Performance evaluation

In this paper, the performance of the algorithm is quantitatively evaluated using precision and recall, where precision indicates how many targets were correctly predicted and recall indicates how many targets were found, calculated as:

$$Precision = TP / (TP + FP) \tag{10}$$

$$Recall = TP / (TP + FN) \tag{11}$$

where: TP is the number of all manually labeled engineering vehicles correctly classified as engineering vehicles; FP is the number of targets similar to engineering vehicles in the picture incorrectly classified as engineering vehicles; FN is the number of unrecognized engineering vehicles.

3.3.3 Test procedure and results

(1) Improvement of candidate frame

Combining the characteristics of small-scale dense engineering vehicles with aspect ratios close to 3:1 or 1:1 and large gradients between pixel edges and backgrounds in the pixel area, the a priori bounding box sizes of (15, 17), (16, 44), (30, 27), (43, 43), (30, 86), (72, 69), (56, 169), (121, 125), (82, 235), and the clustering results are shown in Figure 4.

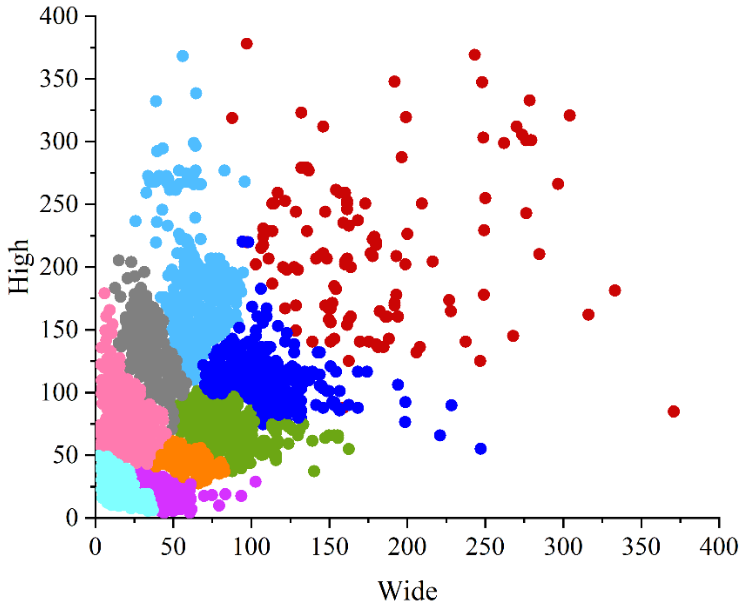

Figure 4: Clustered scatter plot

For the candidate frames before and after improvement, after clustering, the same YOLOv3 network is used for training and tested on the test set, and the test results are shown in Table 1. As can be seen from the table, the average accuracy of the improved YOLOv3 algorithm has been improved by 2.8% compared to the original one, and there are different degrees of improvement in each engineering vehicle.

Table 1: Comparison of clustering results

Engineering vehicle	K-means	K-means++
Crane	0.856	0.88
Concrete mobile	0.821	0.865
Excavator	0.871	0.895
Forklift	0.6	0.631
Concrete mixer	0.86	0.884
Road roller	0.835	0.854
Average accuracy	0.807	0.835

(2) Network Training

The network is built using the Darknet 53 framework and the network is trained on the server. Compare the improved YOLO v3 with the original YOLO v3 algorithm, and for fairness, the batch size, learning rate, learning decay rate, and number of iterations during training will be set uniformly in this experiment. The batch size batch is set to 32, the learning rate is set to 0.001, and the iterations decay at 1000 and 2000 iterations, and the total number of iterations is 2300.

The training results are shown in Figure 5. From the figure, it can be seen that after changing the original binary cross-entropy loss function to CIoU_Loss, the model convergence has been improved, the loss decreases quickly at the beginning of the training, and with the increase in the number of iterations, it is stabilized at about 300 iterations, and the improved model is about 500 training batches faster than the pre-improvement model, and the final value of the network's loss is about 1.3.

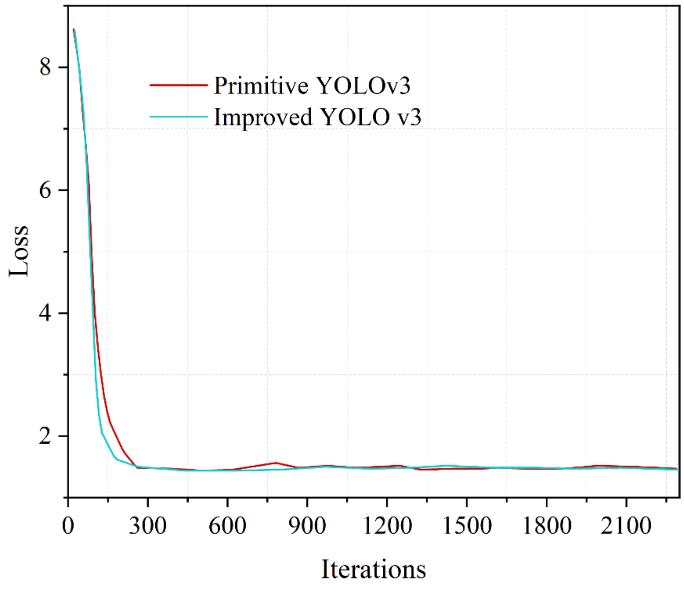

Figure 5: Loss function curve diagram

(3) Performance comparison

In order to verify the effectiveness of the improved network, the original YOLO v3 and the improved YOLO v3 network are compared, and the comparison results are shown in Table 2. The processing time for each image increases from the original 128ms to 155ms, an increase of about 27ms, which may be due to the increase in the model forward propagation time after changing the module, but the recall rate of the image is increased by about 1.6%, the accuracy rate is increased by 1.5%, and the reliability of the network has been improved greatly. The improved network provides better feature extraction and improved detection for small distant targets and better generalization for engineering vehicle detection.

Table 2: Comparison of different network performance

Engineering vehicle	YOLOv5		Improved YOLO v3	
	Recall	Precision	Recall	Precision
Crane	0.929	0.856	0.963	0.871
Concrete mobile	0.928	0.831	0.943	0.847
Excavator	0.965	0.878	0.979	0.893
Forklift	0.747	0.611	0.755	0.631
Concrete mixer	0.962	0.867	0.973	0.878
Road roller	0.709	0.832	0.723	0.848
Average accuracy	0.873	0.813	0.889	0.828

4 Mechanized construction schedule-cost control based on ant colony algorithm

4.1 Establishment of multi-objective model for transmission line engineering construction

During the construction process of transmission line construction project, the duration of each process can be shortened or lengthened according to the change of human, material and other resources. Different durations of each process will affect the duration, cost and quality of the whole project, in order to get the optimal choice, this paper takes the actual duration, cost and quality of the process as decision variables.

4.1.1 Duration utility function

For each determined construction program of the project, the duration of each process is determined, and the utility value of the duration is the sum of the utility value of each process duration, and the duration utility function is shown in equation (12) for a certain range of process durations. The duration utility function is a quantitative relationship between the utility obtained in the project and the process time allocation:

$$U(t)=\begin{cases}\sum_{i\in U} a_i\left(t_i-t_{2i}\right)^2/u, t_i\in\left[t_{1i},t_{2i}\right]\\ 0, t_i\notin\left[t_{1i},t_{2i}\right]\end{cases} \tag{12}$$

where: $U(t)$ is the utility value of duration; t_i is the actual duration of process i; t_{1i} is the shortest duration of process i; t_{2i} is the longest duration of process i; a_i is the utility coefficient of process i; u is the number of processes; and U is the set of all processes.

4.1.2 Cost-utility function

The construction cost of transmission line construction project consists of direct cost and indirect cost. Among them, the direct cost refers to the various costs directly used in the production process, including labor costs, material costs, machinery shift costs, etc.; indirect costs include the cost of management, review and other work on the project. The utility value of the cost is the sum of the utility value of the cost of each process, within a certain cost range, the cost utility function is shown in equation (13). The cost utility function is a quantitative relationship between the utility gained in the project and the cost of the cost required.

$$U(c)=\begin{cases}\sum_{i\in U}\left[\delta_i\left(c_i-c_{2i}\right)^2+\theta_i\right]/u, c_i\in\left[c_{1i},t_{2i}\right]\\ 0, c_i\notin\left[c_{1i},c_{2i}\right]\end{cases} \tag{13}$$

where: $U(c)$ is the utility value of the cost; c_i is the cost at the actual duration of process i; c_{1i} is the minimum cost of process i; c_{2i} is the maximum cost of process i; δ_i are the coefficients of the utility function of the cost; θ_i is the inherent utility value of the cost.

4.1.3 Quality utility function

Transmission line construction project quality is determined by the quality of the work process in the construction process. The quality of each process is good or bad, and ultimately will directly or indirectly affect the quality of the project, so the quality of the process is the most basic link in the formation of project quality. The utility value of quality is the utility value of each process quality and, within a certain quality range, the quality utility function is shown in equation (14). Quality utility function is the quantitative relationship between the utility obtained in the project and the quality standard achieved by the project.

$$U(q)=\begin{cases}\sum_{i\in U}\left[\eta_i\left(q_i-q_{1i}\right)^2+\rho_i\right]/u, q_i\in\left[q_{1i},q_{2i}\right]\\0, q_i\notin\left[q_{1i},q_{2i}\right]\end{cases} \tag{14}$$

where: $U(q)$ is the utility value of quality; q_i is the quality of process i under the actual duration; q_{1i} is the worst quality of process i, i.e., the lowest score after the quality assessment; q_{2i} is the best quality of process i, i.e., the highest score after the quality assessment; η_i is the coefficient of the quality utility function; ρ_i is the inherent utility value of quality.

4.1.4 Schedule-cost-quality equilibrium optimization model

Through the establishment of the duration utility function, cost utility function, quality utility function, it can be learned that the duration of the shortest time, the cost is not the smallest, the quality is not optimal, how to make the three to achieve the Pareto optimal, the need to establish the transmission line construction project duration, cost, quality of the multi-objective optimization model, as follows:

$$\begin{gathered}\max U(t,c,q)=[U(t)+U(c)+U(q)]/3\\ s.t.\quad t_{1i}\leqslant t_i\leqslant t_{2i}\\ c_{1i}\leqslant c_i\leqslant c_{2i}\\ q_{1i}\leqslant q_i\leqslant q_{2i}\end{gathered} \tag{15}$$

4.2 Duration-cost-quality optimization based on ACO algorithm

4.2.1 Co-evolutionary algorithms for multiple swarm ant colonies

Multi-colony ant colony algorithm constructs a population of ants with three objectives: schedule, cost and quality, and gradually searches for an optimized sequence of paths as the ants build solutions. In the ant colony algorithm, it is assumed that there are m ants, each of which represents a project implementation program, and an operation mode is selected for each process in turn. Take any one of the ants as an example for the following illustration, taking each process node as a starting point, the probability that an ant continues to select process j after completing process i is:

$$p_{ij}=\begin{cases}\dfrac{\left[\tau_{ij}\right]^{\alpha}\left[\eta_{ij}\right]^{\beta}}{\sum_{k\in allowed_i}\left[\tau_{ik}\right]^{\alpha}\left[\eta_{ik}\right]^{\beta}}, & \text{If } j\in allowed_i\\ 0, & \text{Otherwise}\end{cases} \tag{16}$$

Eq. (16) where τ_{ij},η_{ij} is the pheromone and heuristic factor on path (i,j), respectively; α,β is the relative importance of the pheromone and the heuristic factor, respectively; and set $allowed_i$ denotes the remaining processes that are allowed to be reachable after the completion of process i.

When the ants pass through a path, they will change the pheromone content on the path, so that the pheromone on the path increases $\Delta\tau_{ij}$, which can be specified as a constant or a function according to the need; at the same time, in order to avoid closing the colony prematurely, the ant colony algorithm sets a pheromone volatilization parameter ρ, which will lead to the path updating the pheromone according to the following equation:

$$\tau_{ij} \leftarrow (1-\rho)\tau_{ij} + \frac{1}{f_k}\Delta\tau_{ij} \tag{17}$$

The f_k in Eq. (17) is the value of the function of the k th goal for which the search is completed. When all ants complete a traversal, the pheromone on the path is globally updated according to a certain strategy.

4.2.2 Algorithm flow

Based on the principle of basic ant colony algorithm, this paper constructs an improved multiple colony ant colony coevolutionary algorithm (MCCAA). For the multi-objective discrete optimization problem, this paper considers three populations searching for Pareto solution sets on behalf of the three objectives of duration, cost and quality, respectively, which are searching on the three-dimensional network nodes at the same time, and the three populations coordinate the searching process by hybridizing the pheromone when they meet the maximal or minimal constraints of the duration, cost and quality. The basic idea is: first initialize the three ant populations and pheromone, at the same time, set a target threshold for each goal, each population in the same network to search independently, when an ant of any population completes the search, it will form a new solution into the objective function, and the target threshold for comparison, if the trait is better than the set target value, then the pheromone generated at this point in the search path with the other two populations The pheromone on that pathway is hybridized, thus promoting coordination between the different populations, while the new solution formed is recorded in the solution set. If the searched new solution duplicates with a non-inferior solution in the solution set, the pheromone on that path is reduced according to certain principles to avoid falling into premature stagnation and local optimal solutions.

4.3 Multi-Objective Program Selection Methodology for Construction Projects

4.3.1 Selection of Methods for Determining the Weights of the Objective Function

In this paper, the mathematical model of resource allocation covers multiple evaluation indicator functions, multi-objective decision-making analysis of the problem of the first task is to determine the weight coefficients between the evaluation indicators, the weight coefficients are objective, rationality largely affects the final evaluation of the target results.

At present, the evaluation method of indicator weights can be summarized into three categories according to the source of weight data and the focus of the evaluation method: subjective empowerment, objective empowerment, and subject-objective integration empowerment. Most of the subjective empowerment methods use consulting and experience scoring to determine the weight value, and the common methods include hierarchical analysis method (AHP), comprehensive index method, expert survey method, and efficacy coefficient method. This kind of method is determined by the subjective experience of experts because of the judgment matrix, it is more difficult to exclude the subjective factors on the weight of the indicators, the analysis, decision-making process is not quantitative enough, the accuracy requirements of the program may be higher with the actual situation to produce a large deviation;

objective weighting method mainly includes entropy weighting, principal component analysis, the ideal solution method (TOPSIS) and so on. Such methods combined with the actual data, the calculation is more objective, to a greater extent, to avoid the subjective factors on the weight indicators; subjective and objective integration of empowerment method is usually two types of empowerment methods, such as entropy weight, hierarchical analysis method combination. Integrated empowerment is generally only a simple combination of indicator weights, and the mathematical derivation of weight depth integration is not in-depth.

This paper adopts a method of determining objective weight indicators based on the combination of entropy weight method and ideal solution method. The objective assignment lacks certain subjective focus, is based on actual production data with obvious differentiation, is objective and fair, and can better reflect the degree of competition and influence of each indicator, and meets the requirements of manufacturing resource allocation.

4.3.2 Steps for determining the weights of the entropy weight TOPSIS method

Entropy, a measure of uncertainty in information theory, is inversely proportional to information. Entropy weight method as a kind of objective assignment method, its basic principle is in accordance with the size of the indicator numerical size of the degree of variation in the amount of information reflected in the size of the determination of weights.TOPSIS that is, the ideal solution method, through the determination of the evaluation of the object, the indicator of the optimal, the inferior solution distance to the distance proximity to the evaluation of the object, the indicator of the sequential ordering. In this paper, entropy weight TOPSIS method is used to solve the weights.

The specific application steps of entropy weight TOPSIS method are as follows:

Step1: Construct judgment matrix. Assuming that the object to be evaluated $O=\left(O_1,O_2,\cdots,O_m\right)$, the evaluation indexes $I=\left(I_1,I_2,\cdots,I_n\right)$, and the quantitative value of the object O_i to the indexes I_j is written as x_{ij}, and the initial evaluation matrix $X=\left(x_{ij}\right)_{m\times n}$ is obtained:

$$X=\begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & & \vdots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \tag{18}$$

Step2: Normalization of judgment matrix. Evaluation indicators of different sizes and ranges of values, it is difficult to compare directly, the data must be standardized, the standardized form is divided into the larger the better type (isotropic), the smaller the better type (inverse), respectively, as shown in equation (19), equation (20). Where $\max\left(x_j\right),\min\left(x_j\right)$ denote the maximum and minimum values of the indicator j respectively. The normalized judgment matrix is shown in equation (21), and the normalized data are in the interval $[0,1]$:

$$x'_{ij}=\frac{x_{ij}-\min\left(x_j\right)}{\max\left(x_j\right)-\min\left(x_j\right)} \tag{19}$$

$$x'_{ij} = \frac{\max\left(x_j\right) - x_{ij}}{\max\left(x_j\right) - \min\left(x_j\right)} \tag{20}$$

$$X' = \begin{bmatrix} x'_{11} & x'_{12} & \dots & x'_{1n} \\ x'_{21} & x'_{22} & \dots & x'_{2n} \\ \vdots & \vdots & & \vdots \\ x'_{m1} & x'_{m2} & \dots & x'_{mn} \end{bmatrix} \tag{21}$$

Step3: Determine the evaluation index entropy H_j. Where, in order to make $\ln f_{ij}$ meaningful, the characteristic specific gravity f_{ij} is corrected, and the expression is shown in Eq. (22) and Eq. (23):

$$H_j = -\left(\sum_{i=1}^{m} f_{ij} \ln f_{ij}\right) \Big/ \ln m \tag{22}$$

$$f_{ij} = \frac{1 + x'_{ij}}{\sum_{i=1}^{m}\left(1 + x'_{ij}\right)} \tag{23}$$

Step4: Calculate the entropy weight W_j as shown in equation (24):

$$W_j = \left(1 - H_j\right) \Big/ \left(n - \sum_{j=1}^{n} H_j\right) \tag{24}$$

Step5: Calculate the evaluation index weight set $R = \left(r_{ij}\right)_{m\times n}$, as shown in equation (25):

$$R = \left(x'_{ij} \times W_j\right)_{m\times n} \tag{25}$$

Step6: Determine the positive and negative ideal solutions Q_+, Q_-. Where $Q_+ = \left(r_1^+, r_2^+, \dots, r_n^+\right), Q = \left(r_1^-, r_2^-, \dots, r_n^-\right)$.

Step7: Calculate the distance d_i^+, d_i between the scheme and Q_+, Q_-:

$$d_i^+ = \sqrt{\sum_{j=1}^{n}\left(r_{ij} - r_j^+\right)^2} \tag{26}$$

$$d_i^- = \sqrt{\sum_{j=1}^{n}\left(r_{ij} - r_j^-\right)^2} \tag{27}$$

Step8: Calculate how close the solution is to the ideal solution:

$$c_i = d_i^- / \left(d_i^+ + d_i^-\right) \tag{28}$$

The entropy weight TOPSIS method calculates the entropy weight can be used as the objective weight of the evaluation index, while the larger the value of closeness C_i, the higher the object reliability.

4.4 Analysis of engineering examples

This paper takes the 220kV transmission line construction project in the Gobi desert environment as an example, the cumulative 103 foundations in this project section, and the foundations are all hollowed out foundations. The construction unit can choose the whole process of mechanized construction and manual construction. In the whole process of mechanized construction, the mechanical rotary speed is calculated according to 5m/h. Considering the time of equipment installation and commissioning and transfer, the construction efficiency of a rotary drilling rig is estimated to be 1 foundation/day on average, in which the one-time investment is RMB 8800 yuan, including cranes and wire ropes, etc., and the cost of RMB 10,750 yuan is incurred for each working day. The whole process of manual construction to the construction of the project at a certain period of time, for example, more than one person to cooperate in an average of 8 days to complete a foundation excavation, the workers' wages of about 480 yuan / day. 2 programs are considered road construction, labor management, supervision, acceptance, such as the duration and cost of the project.

In order to better fit the actual project, the whole process of mechanized construction and manual construction variables range from 1 to 10 groups and are freely combined. The multi-objective functions are f_{Duration} and f_{Costs}, where f_{Duration} is the construction duration and f_{Costs} is the construction cost. In this paper, the improved multi-objective ant colony algorithm is used to solve the problem, where the multi-objective ant colony algorithm controls the parameters $\alpha = 1, \beta = 0.2, \rho = 0.1, Q = 1, m = 10$ and $NC_{\max} = 100$.

4.4.1 Algorithm parameterization

In the ant colony algorithm set up 3 populations, through the simulation in matlab environment for many times and then set up each population to take 70 ants, the number of colony iteration is 100, α=1, β=4, ρ=0.1, Q_0=1. The number of populations is 60 in the parameter setting of the multiobjective particle swarm algorithm, the maximal number of iterations is 100, inertia weight w=1, individual learning coefficient c_1=2.05, global learning coefficient c_2=2.05.

4.4.2 Experimental results and analysis

The simulation operation of the basic ant colony algorithm and the multi-objective co-evolutionary ant colony algorithm is carried out in Matlab environment, and the three-dimensional scatter plot of the Pareto solution of the project's duration-cost-quality after the fusion of the two algorithms is shown in Fig. 6, and the optimized construction processes of the two algorithms are shown in Table 3.

From the table, there are 10 construction process combination schemes after the algorithm improvement, and there are two construction process combination schemes obtained by the basic ACO algorithm. Figure 6 shows that there are multiple pareto solutions, and the improved algorithm has more choices for the manager. Considering the table, scheme 7 has the shortest duration of 811 days, lower cost of 15068.17, and high quality of 79.61; in terms of quality, scheme 3 has the highest quality of 83.91. It can be seen that the improvement of the basic ant colony algorithm is effective, and it can be used in multi-objective optimization of management of the project.

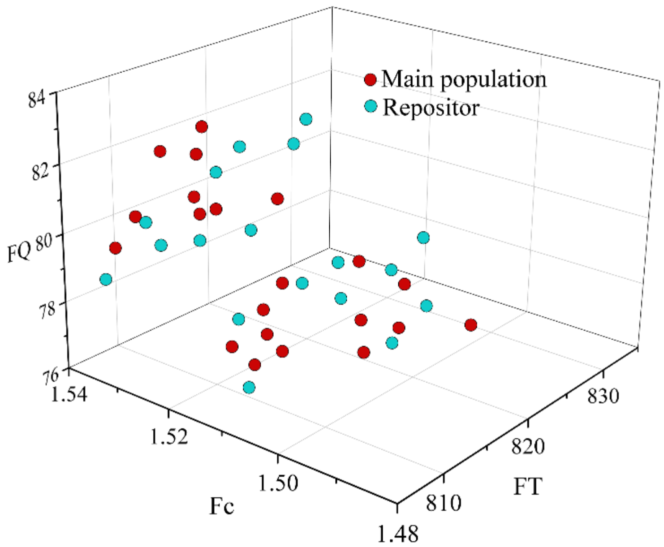

Figure 6: Optimization solution 3D scatter plot

Table 3: Construction work parameters

Serial number	Production processes												
	1	2	3	4	5	6	7	8	9	10	Construction period/d	Prime cost/ten thousand yuan	Quality
Improved Ant Colony Algorithm													
1	1	1	1	2	1	1	2	2	2	2	819	15324.17	81.91
2	1	1	1	2	1	2	2	2	2	2	827	15018.89	79.68
3	1	1	2	1	1	1	1	2	2	1	826	15344.17	83.91
4	1	2	1	2	1	1	2	2	2	1	821	15306.17	82.41
5	1	2	1	2	1	1	2	2	2	2	817	15311.17	82.03
6	2	1	1	2	1	1	2	2	2	2	815	15351.67	81.63
7	2	1	1	2	1	2	2	2	2	2	811	15068.17	79.61
8	2	2	1	2	1	2	1	2	2	1	823	15031.39	80.21
9	2	2	2	1	1	2	1	1	2	1	824	15083.17	82.03
10	2	2	2	1	1	2	1	2	2	1	821	15075.17	81.73
Basic ant colony algorithm													
1	1	2	1	2	1	2	2	2	2	1	829	15000.89	78.18
2	1	1	2	1	1	1	1	1	1	1	839	15452.67	84.61

4.4.3 Programmatic options

1) Entropy value method to solve the weights

(1) From Table 3, we can get that the alternative $m=10$, the evaluation index $n=3$, the original index data matrix is $X=\left(x_{ij}\right)_{10\times 3}$, where $i=1,2,\cdots 10;\ j=1,2,3$:

$$X=\begin{bmatrix} 816 & 15112.2 & 80.21 \\ 818 & 15527.4 & 82.18 \\ \vdots & \vdots & \vdots \\ 822 & 15463.7 & 81.42 \end{bmatrix}_{10\times 3} \tag{29}$$

(2) Normalize the raw indicator data matrix by calculating the weight r_{ij} of the i th scenario under the j th indicator to obtain the normalized matrix R:

$$R = \begin{bmatrix} 0.4109 & 0.9317 & 0.5765 \\ 0.5226 & 0.9725 & 0.4011 \\ \vdots & \vdots & \vdots \\ 0.7203 & 0.7431 & 0.2914 \end{bmatrix}_{10\times3} \tag{30}$$

(3) Information entropy of the j th indicator:

$$H = (47.11, 48.47, 49.92) \tag{31}$$

(4) The weights of the indicators, as shown in Table 4.

Table 4: Weights of indicators

Weight	Construction period	prime cost	Quality
e_j	0.246	0.249	0.251

2) TOPSIS method of sorting

(1) Obtain the normalized judgment matrix:

$$Y = \begin{bmatrix} 0.4239 & 0.9439 & 0.5862 \\ 0.5149 & 0.9903 & 0.3952 \\ \vdots & \vdots & \vdots \\ 0.7288 & 0.7528 & 0.4833 \end{bmatrix}_{10\times3} \tag{32}$$

(2) Determine the positive and negative ideal solutions:

Determine the positive and negative ideal solutions, the positive and negative ideal solutions for each indicator are shown in Table 5.

Table 5: Positive and negative ideal solutions of indicators

	Construction period	prime cost	Quality
Positive ideal solution	0.00197	0.00002	0.24439
Negative ideal solution	0.24452	0.24811	0.00163

(3) Calculate the Euclidean distance between each scheme and the ideal solution

According to the Euclidean distance between each scheme and the positive and negative ideal solutions, the relative closeness of each scheme is calculated, and the results are shown in Table 6. The solutions are ranked according to the size of their relative closeness C_i. Since $C_8 > C_4 > C_2 > .... > C_5$, so the order of the program's advantages and disadvantages is: program 8>program 4>program 2>...>program 5, “>” stands for “better than”. According to the above results can be concluded that the optimal program for the program 8, in the network planning diagram of the key lines are: 1 → 2 → 4 → 6 → 7 → 8 → 9 → 10.

Program 8 project duration is 802 days, 21 days earlier than the previous required duration, the total project cost is 139,781,900 yuan, saving 10,532,000 yuan compared with the previous period, in which the project quality index is 83.33, improved by 3.12, then the project quality grade is excellent. Therefore, the constructed multi-objective co-evolutionary ant colony algorithm for transmission line construction project has certain effectiveness and practicality.

Table 6: Euclidean Distance and Relative Closeness between Positive and Negative Ideal Solutions

Scheme	The Euclidean Distance Between the Positive Ideal Solution	The Euclidean Distance Between the Negative Ideal Solution	Relative proximity
1	0.3334	0.2250	0.6061
2	0.3558	0.1886	0.6642
3	0.3425	0.2363	0.6006
4	0.3609	0.1830	0.6743
5	0.1353	0.4153	0.2461
6	0.2049	0.3989	0.3424
7	0.1479	0.3979	0.2719
8	0.3822	0.2136	0.6514
9	0.3592	0.1867	0.6687
10	0.2369	0.3442	0.4122

5 Conclusion

In the context of transmission line construction project detection, an improved YOLOv3 engineering vehicle detection algorithm is proposed, by combining the k-means++ algorithm, using DIOU to improve the positional loss, and brightness enhancement of the dataset images, which is favorable to the improved YOLOv3 network recognition. Comparative experimental results show that the proposed improved YOLO v3 algorithm can realize the detection of small targets at a long distance and improve the accuracy of target detection. At the level of transmission line construction project management, based on the ant colony algorithm to introduce the idea of co-evolution, a multi-objective co-evolutionary ant colony algorithm is proposed to take the 220kV transmission line construction project in the Gobi Desert as an example, and with the help of entropy weight TOPSIS method to complete the program preference, and the optimal program is program 8, and the key lines in the network planning diagram are: 1→2→4→6→7→8→9→10.

In summary, the method proposed in this paper provides technical support for the intelligent detection and multi-objective control of transmission line construction, improves the automation and refinement level of transmission line construction engineering, and has certain practical value.

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