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INTELLIGENT BRAKE DESIGN BASED ON RBR AND CBR HYBRID REASONING

Abstract. *For intelligent design of a brake, different knowledge should be obtained effectively from the huge design knowledge sources.To improve efficiency of case-based reasoning in design of brake products and accurately reason the required optimal design proposal, by combining design characteristics of the brake, this paper proposes one CBR-RBR hybrid reasoning method by studying and analyzing brake design flow and field knowledge,by combining the phase hierarchical structure of product design, different reasoning mechanisms are used in the design of the brake proposal and specific parameterized design. The CBR is used to reason the design of brake proposal, structural type of specific type and selection of general deployment mode. RBR is used to reason the case adaptions of main structures, size parameters, structural models and materials used. The general structure design of the brake is used to explain the whole process.*

Key words: Brake; Hybrid reasoning; Intelligentized design

Introduction

Currently, the 3D design of the brake is generally modeled using bottom-up method. The product is designed by continuously accumulating models. The repeated labor is over 80% of the whole design workload when an engineer completes design of the brake [1].

For intelligent design of a brake, different knowledge should be obtained effectively from the huge design knowledge sources. By combining design characteristics of the brake, this paper uses the CBR-RBR hybrid knowledge reasoning method. By combining the phase hierarchical structure of product design, different reasoning mechanisms are used in the design of the brake proposal and specific parameterized design [2]. The CRB is mainly used to reason brake proposal design, structural type of specific types and selection of general deployment mode. The RBR is mainly used to reason case adaption of main structures, sizes and parameters, structure model and material used when the type of brake has been determined, offering basis for case adaption. Figure 1 is the flow chart.

Analyze the design characteristics of the brake

For brake design, identify the structural type of the specific brake system based on the performance parameters of the whole vehicle and consider distribution of the torque of the front and rear wheel brake. Plentiful parameters are required in this process, so design and calculation process of a new brake is relatively complicated.

As the kernel secure component in tractor's driving, besides deceleration and stop, the brake will also ensure that the tractor can park on the slope and the tire does not slide on the slope. Therefore, certain structural strength and rigidity should be ensured in the design. The brake should play its role securely and stably in operation. In addition, the following design requirements should be considered:

1. Reliability: Enough brake torque should be provided. Main parts and operation mechanisms should have certain strength and rigidity, and feature higher heat dissipation performance, water resistance and wear resistance.

2. Manipulation: Manipulation force: $P = 200 \sim 400\,N$ and $S = 60 \sim 100mm$. The brake force can be quickly and stably executed with push-down and release of the brake pedal. The double-side brake should be coordinated.

3. Sealing performance: Ensure that brake effect is not affected due to pollution on the friction surface.

4. Environmental protection performance: Besides the above performance indexes, the noises of the brake system should be as small as possible and scattering asbestos fiber should be reduced.

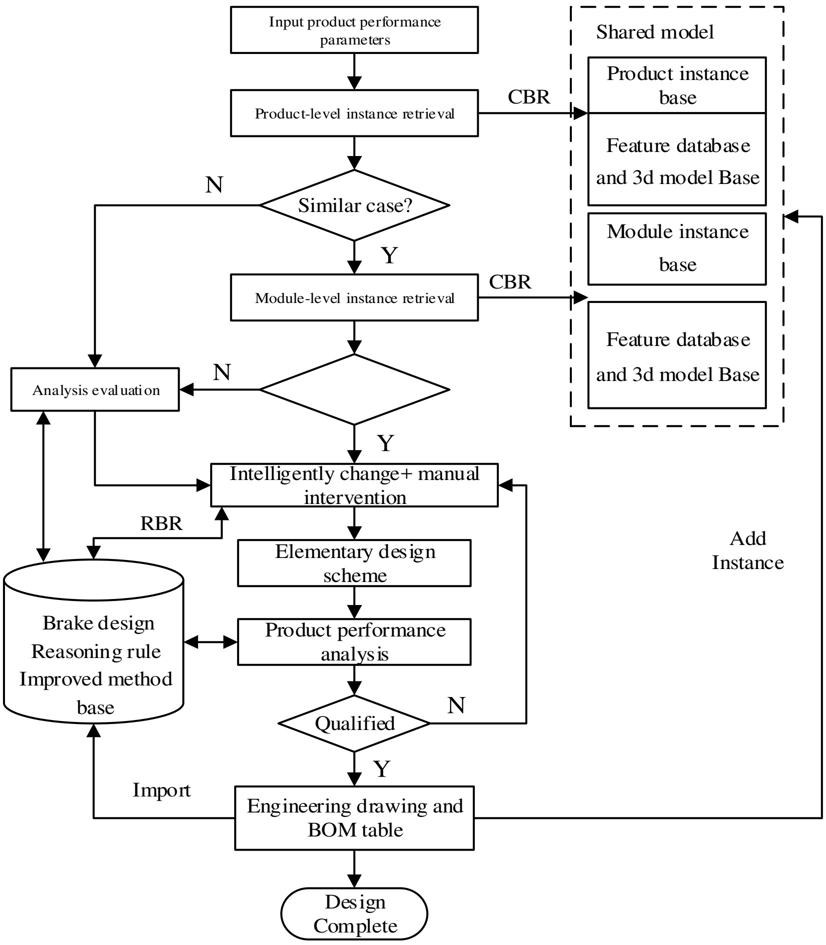

Figure 1 – General flow of hybrid reasoning of intelligent brake design

Hierarchical case retrieval of brake based on CBR

Case retrieval

Case retrieval is the key technology of CBR system and is also the core to realize intelligent design. The case retrieval indicates that the system can retrieve a case same as the target or similar to the target from the case library after designers input the design parameters. The similarity among cases is the key evaluation standard to measure retrieved cases.

Case retrieval method

Now diversified case retrieval methods are generated with the emergence of different design systems and diversification of characteristic attributes of specific cases. Now retrieval methods most frequently used include template method, nearest neighbor method, induction method and knowledge guidance method [3; 4].

Steps of case retrieval

The cases are retrieved via the following three steps: feature recognition → case matching → optimal target. The specific process is shown as figure 2.

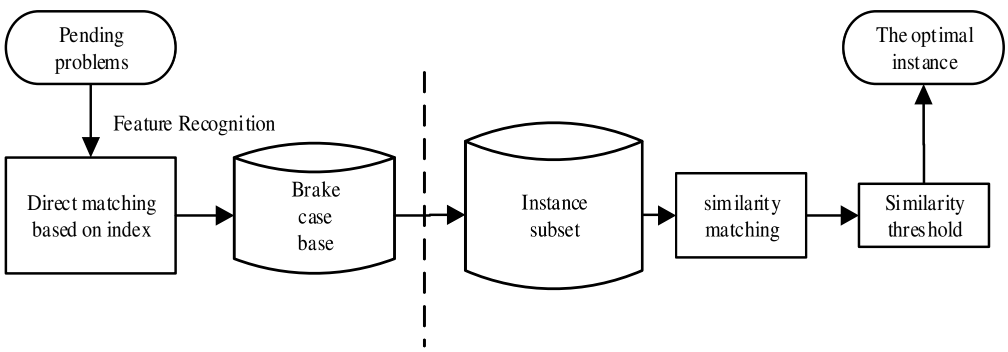

Figure 2 – General flow of brake case retrieval

Case matching

Case matching means to retrieve the most suitable cases from the design case library for design issues with a solution according to the design requirements set by users. It includes the index-based direct matching and further similarity algorithm-based case matching. The index-based direct matching mainly identifies partial attributes as the constraints from plentiful attributes in the cases at the beginning of the design and select case sub-net similar to the design issue. The similarity algorithm-based case matching identifies the best design case by calculating similarities among cases.

Case adaption

Case adaption means to add, delete and replace reused cases according to certain rules according to different design requirements in order to finally solve new issues [5].

Now the case adaption methods include conversion method, replacement method, specific target driving method and derivative repetition method [6]. The rules for adaption of the brake design are described as follows:

Rule 1: IF the tractor is matched and the brake is installed on the front wheel, THEN the disk brake is selected.

Rule 2: IF the matched vehicle is the high-horse tractor and the brake is installed on the rear wheel, THEN the drum brake is selected.

Rule 3: IF the matched vehicle is the small-horse tractor and the brake is installed on the rear wheel, THEN the shoe brake is used.

Rule 4: IF the matched vehicle is the tractor and the brake is installed on the rear wheel, THEM the drum brake is used.

The following method is used to revise the case in design of the brake and finally realize the reuse of the case based on knowledge.

1. After the retrieval conditions are inputted, if the retrieved design cases fully match the requirement of the inquiry case, this design case can be directly used. However, occurrence probability of such case retrieval is small [7].

2. If the retrieved design cases are fully different from the inquiry case, the cases should be changed according to actual conditions.

If similar cases are not retrieved or the similarity of retrieved cases is low, the cases should be designed by referring to the existing cases, or cases are redesigned and stored by using the up-bottom parametric modeling method [8].

Analysis on brake application case

With the general design structure of the leading shoe cam drum brake as one example, this paper describes the application process of the above case retrieval method. Retrieval of the brake design case is classified as the module case retrieval according to classification standard by combining design rules and characteristics of the routine brake [9]. Specific implementation process is described as follows.

1. Generate inquiry case $P_{1,0}$ according to the general structural design requirements of the leading shoe drum brake and assign weights to the features of different attributes by using the hierarchical analysis method [10], shown as table 1.

*Table1 – **Brake instance property sheet***

Sequence Number	Property name	Property value	Weight
1	Radius of brake R/mm	90	0.25
2	Brake shoe angle of contact θ/°	96	0.20
3	Distance between centre of cam and center of Brake drum e/mm	72	0.18
4	Width of friction liner b/mm	14	0.15
5	Friction liner start angle θ_0/°	42	0.12
6	Distance between rotation centre of brake shoe and center of Brake drum a/mm	72	0.10

2. To improve case retrieval efficiency and reduce calculation complexity of further similarity, select the qualified design cases from case set $C_{1,k}$ by combining the key user design requirements and utilizing the index-based direct matching method $(85.5mm \le R \le 94.5mm,$ $91.2° \le \theta \le 100.8°$, namely search brakes with the range that differences between the radius of the brake drum and width of friction lining are within ±5%), shown as table 2.

3. To search the brake drum radius, brake shoe cornerite and cam driving mode in the attributes of the brake cases, the case 1, 4 and 6 in table 4-3 satisfy the search and retrieval conditions "$85.5\text{mm} \le R \le 94.5\text{mm}$, $91.2° \le \theta \le 100.8°$, and the cam is driven in a circle manner". Matching similarities of three cases to the inquiry case $P_{1,0}$ will be calculated according to the above calculation method. The steps are described as follows:

– Calculate similarities of the attributes: Select the "brake drum radium" with the maximal weight to calculate the matching similarity according to the characteristic weights of the attribute. The similarity calculation of this attribute belongs to matching between the values. By referring to the formula in the table, the results are described as follows:

*Table 2 – **Brake design instance property sheet***

Sequence Number	Radius of brake R/mm	Brake shoe angle of contact θ/°	Cam Happening manner	Distance between centre of cam and center of Brake drum e/mm	Width of friction liner b/mm	Friction liner start angle θ_0/°	coefficient of friction	Distance between rotation centre of brake shoe and center of Brake drum a/mm
1	92	96	circular	76	14	42	0.4	76
2	92	96	involute	74	18	42	035	74
3	88	92	Archimedes spiral	72	16	44	0.4	72
4	94	94	circular	74	14	43	0.4	74
5	90	100	involute	80	17	40	0.38	80
6	89	98	circular	76	15	41	0.4	76

$$\text{sim}\ (92{,}90) = 1 - \frac{|92-90|}{94.5-85.5} \approx 0.778,$$

$$\text{sim}\ (94{,}90) = 1 - \frac{|94-90|}{94.5-85.5} \approx 0.556 \text{ and}$$

$$\text{sim}\ (89{,}90) = 1 - \frac{|89-90|}{94.5-85.5} \approx 0.889$$

Eliminate the case 6 and reserve the case 1 and 4 according to the set threshold $V = 0.7$;

– Calculate total similarity of the case: get the total similarity between design case 1 and inquiry case $P_{1,\ k}$ based on the computational formula, namely $S_1 = S\left(P_{1,k}C_{1,1}\right) \approx 0.782$ and $S_4 = S\left(P_{1,k}C_{1,4}\right) \approx 0.756$;

– Get the optimal matched design case: Compare total similarity S_1 and S_4 and select the case 1 that is of high total similarity as the optimal matching case.

Figure 3 is the resulting parameterized model of brake.

Figure 3 – The resulting parameterized model of brake

Conclusions

By studying and analyzing the brake design flow and field knowledge, this paper proposes a hybrid reasoning method based on CBR-RBR and applies it into the intelligent design of the brake. First, introduce the basic knowledge on intelligent design knowledge of reasoning of brake and propose hybrid reasoning method with CBR as the main body and integrating RBR reasoning technology by combining design characteristics of the brake; Secondly, adopt the similarity-based hierarchical case retrieval algorithm for the case retrieval and adaption problems in the brake design, calculate matching similarities between cases, finally get the optimal matched design cases, and change and complete design of new cases by using knowledge-based intelligent case; Finally, the whole process is illustrated using the general structural design of the brake.

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ІНТЕЛЛЕКТУАЛЬНА РОЗРОБКА ГАЛЬМ НА ОСНОВІ ГІБРИДНИХ МІРКУВАНЬ RBR ТА CBR

Abstract. *Для інтелектуального дизайну гальм різні знання повинні бути ефективно отримані з величезних джерел знань про проект. Для підвищення ефективності випадкових розрахунків при проектуванні гальмових виробів і точних причин потрібна оптимальна конструктивна пропозиція, що поєднує конструктивні характеристики гальм, цей документ пропонує один метод гібридного обгрунтування CBR-RBR, вивчаючи та аналізуючи перебіг конструювання гальм та знання, об'єднуючи фазову ієрархічну структуру дизайну продукту, різні конструктивні механізми,що використовуються при проектуванні гальмівної прдукції та конкретний параметризований дизайн. CBR використовується для пояснення дизайну гальмівної пропозиції, структурного типу конкретного типу та вибору режиму загального розгортання. RBR використовується для предметної адаптації основних структур, параметрів розміру, структурних моделей та використаних матеріалів. Загальний дизайн конструкції гальма використовується для пояснення всього процесу.*

Keywords: гальмо; гібридне міркування; інтелектуальний дизайн

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