Application of an Expert System for the location decision of Dimension Marking within a graphic drawing sheet for a metal grating production

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Abstract

GDS (Grating automatic Drawing System), which is an automatic design system of metal products called grating, is a system that produces various detailed drawings on the basis of information within a Plan Drawing that represents layout of the gratings such as locations, shapes, directions, etc. However, automatically produced drawings by GDS do not fully satisfy the standard of the general dimension marking method used among the layout designers. The lack of this standard quality mainly results from the fact that overlapping among dimension markings appears frequently. To solve the overlapping problem we applied the rule-based expert system. The rules for the expert system are designed based on the expertise of skilled layout designers within the grating production lines.

Keywords:

GDS; grating; detailed; drawings; dimension marking; rule-based expert system

Introduction

This paper is focused on GDS (grating automatic drawing system) that automates the design phase of a metal grating production process. GDS is a CAD system that analyzes a drawing and generates drawings to be used by the manufacturing process beyond the initial automatic drafting of a Plan Drawing that represents the layout of the gratings such as locations, shapes, directions, etc. Figure 1 shows gratings and fields using a grating.

GDS generates the following three types of drawings on the basis of grating information on the Plan Drawing.

1. BM-List : shows statistical information for allocated grating objects on graphic types.

2. Item Drawing : necessary for individual grating production and contains marked dimensions for each grating.

3. Inspection Drawing : This is a drawing to test the gratings after they are manufactured.

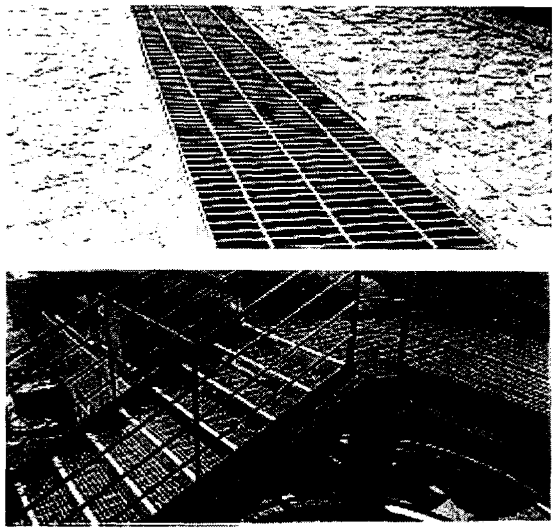

Figure 1- Grating types and fields

However, in case of the Item Drawing and the Inspection Drawing various problems emerged while indicating the dimensions automatically. The dimension marking method being used at GDS was as follows : The horizontal dimension value was indicated above the horizontal line and the vertical line dimension value was indicated on the right side of the vertical line and these methods are applied in all cases. Figures 2 and 3 show the automatic dimension marking of gratings using GDS and the following problems emerged:

① There should be dimensions for horizontal lines and vertical lines to the diagonal lines.

② Dimension lines do not have the proper line alignment.

③ Quite frequently there is overlapping of dimension lines.

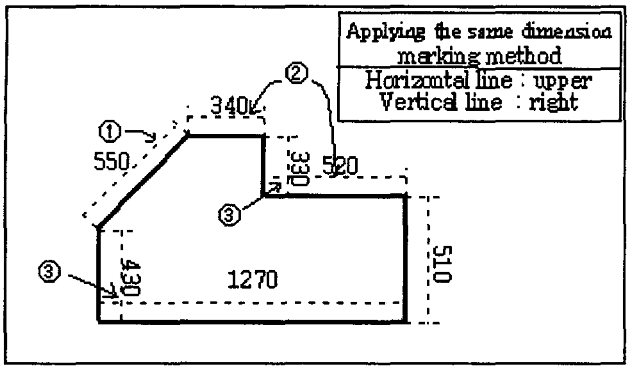

Figure 2 - Item Drawing 1 applying the same method

④ There is overlapping between dimension values.

⑤ The diameter of inside a circle is shown but no central dimension for the location of the circle.

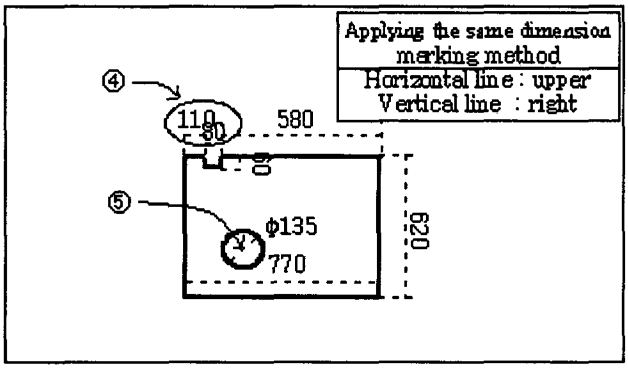

Figure 3 - Item Drawing 2 applying the same method

To solve such problems we attempted to apply the expert system which has the ability to inference and a flexible expression of knowledge [1,2] to satisfy the need for a general dimension marking method and to minimize overlapping among indications of dimension through deciding the position for dimension markings.

Background

The expert system is a computer-based system that uses knowledge, facts and reasoning techniques to solve problems that normally require the abilities of human experts [3,4,5,6,12].

The rule-based expert system is an expert system that uses rules among knowledge representation schemes. There are two main components of a rule based expert system – the knowledge base and the inference engine [6,7]. The inference engine uses the information provided to it by the knowledge base and leads the system user to the advice that he is seeking.

In the expert system, many expert system control strategies, forward chaining, backward chaining, event-driven control, pattern matching and so on, are in use [6,7]. Forward chaining is typical of these, and it is the process of moving from the IF patterns to the THEN pattern, using the IF patterns to identify appropriate situations for the deduction of a new assertion or the performance of an action. During forward chaining, whenever an IF pattern is observed to match an assertion, the antecedent is satisfied. Whenever all the IF patterns of a rule are satisfied, the rule is triggered. Whenever a triggered rule establishes a new assertion or performs an action, it is fired [7].

The knowledge base is the codified form of the knowledge of a human expert on a particular subject and it consists of predicate calculus facts and rules about the subject at hand [8,9].

Rules consist of IF (condition) and THEN (action) [6,10]. The IF pattern is a pattern that may match one or more of the assertions in a collection of assertions. The THEN pattern specifies new assertions to be placed into working memory that is the collection of assertions.

Facts take the form of a logical expression that consist of predicates or attributes and values specifically associated with knowledge based expert systems. Facts represent a state at a particular point [11].

The following are part of the conflict resolution scheme [7].

1. Rule ordering : Arrange all rules in one long prioritized list. Use the triggered rule that has the highest priority. Ignore the others.

2. Context limiting : Reduce the likelihood of conflict by separating the rules into groups, only some of which are active at any time.

3. Data ordering : Arrange all possible assertions in one long prioritized list. Use the triggered rule that has the condition pattern that matches the highest priority assertion in the list.

Design of an expert system for the location decision of dimension marking.

Figure 4 illustrates the application of the expert system on GDS for dimension marking. The developer is composed of the knowledge base with the method of dimension marking of the design expert. If the location of dimension marking is requested by the Drawing Data Generator, the inference engine decides the location of dimension using the knowledge base.

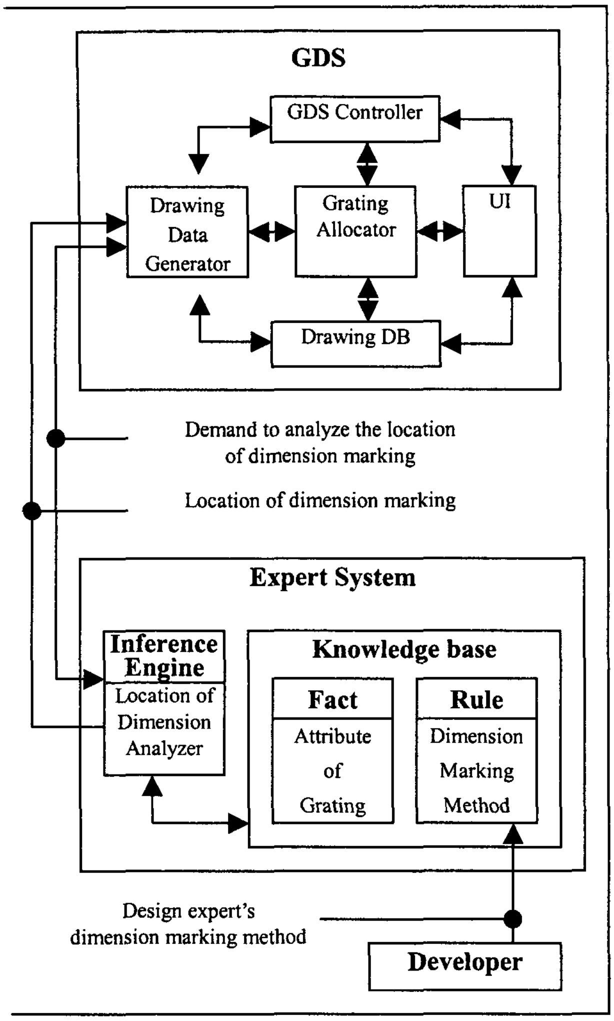

Figure 4 - GDS and expert system for the location decision of dimension marking

Application of expert system

Location of dimension marking (Goal)

Goal is divided into 13 cases such as Top 1, Top 2, Down 1, Down 2, Left 1, Left 2, Right 1, Right 2, Inside, Center 1_area, Center 2_area, Center 3_area, Center 4_area as shown in Figure 5 and Figure 7. If the sub-entity (elements of grating - line, arc and circle) is a line as in Figure 5, top and down are the horizontal line goal and left and right are the vertical line goal. And if the line is a diagonal, dimension marking for length/width shall be shown. The inside can be a goal relevant to all sub-entity and dimension marking is located in the inside of entity. And the division of goals into 1 and 2 is to escape any repetition between images showing dimension values.

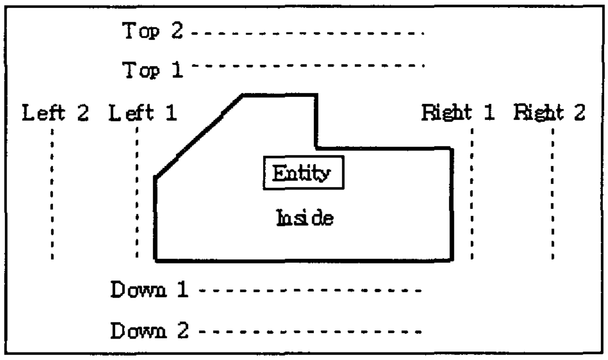

Figure 5 - The location of goal

The goal decides whether there is any intersection between imagined lines and the entity when making vertical or horizontal lines which connect sub-entities and each goal. If the intersection is not on an imagined line, the goal connecting with the imagined line is decided as the location of the dimension, and if intersections are on all imagined lines, the inside is decided as the location of dimension markings. In the case of Figure 6, the dimension location of the sub-entity is shown on Top 1.

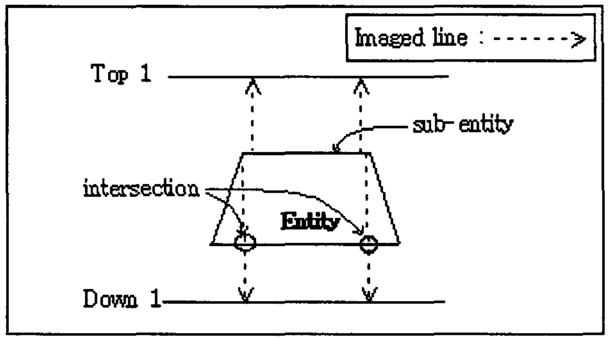

Figure 6 - The method to decide the goal of sub-entities

Figure 7 shows the goal to mark the dimension on the center point of a circle which is inside of the entity. Four hypothetical areas (Center 1_area to Center 4_ area) divide the entity center and the dimension indication of the center point of the circle is located in the area included in the center point of inside the circle.

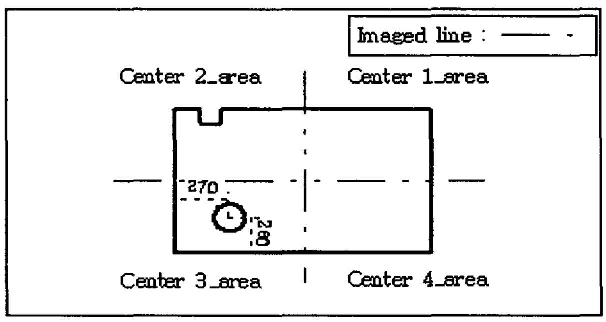

Figure 7 - Goal to mark the dimension of the center point of inside the circle

Attribute of a grating (Fact)

Figure 8 shows facts. There are initial facts for entity (grating object) and sub-entity (attributes of grating to describe dimension). There are sub-entity types (straight, arc, circle) and straight types (width, length, diagonal), and there are the goals of the sub-entity (Top 1, Top 2, Down 1, Down 2, Left 1, Left 2, Right 1, Right 2, Inside, Center 1_area, Center 2_area, Center 3_area, Center 4_area), Diagonal-width, Diagonal-length, indicated horizon and vertical of diagonal line and Top-gap, Down-gap, Left-gap, Right-gap for judging the overlapping between dimensions. In case the sub-entity is a circle, there are Inside_circle for judging inside or outside of the entity with regard to the location of a circle, and Center 1_area, Center 2_area, Center 3_area, Center 4_area for marking the center point of a circle in the case of inside a circle.

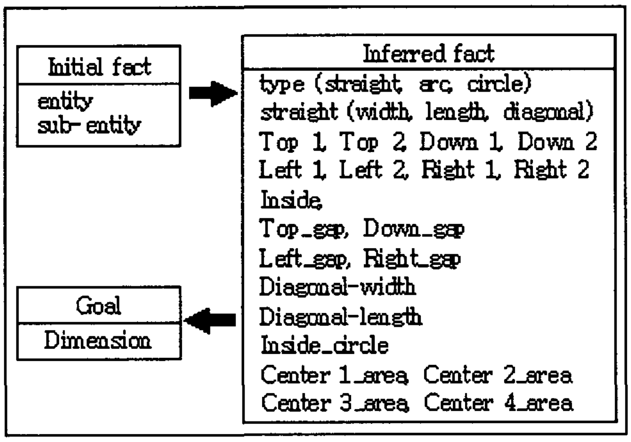

Figure 8 - Fact

Dimension marking method of drawing (Rule)

The attribution of a sub-entity is expressed and compared on condition of each rule as facts and a goal is acquired by an inferred fact of new attribution into the sub-entity under the management decision of a rule. The following are some of the rules :

Rule 27 : IF type = width ^ Top1 hasn't an intersection = true.
THEN dimension Goal is Top 1.

Rule 28 : IF Goal = Top1 ^ Top_gap hasn't a gap = true.
THEN dimension Goal is Top 2.

Rule 29 : IF type = width ^ Down1 hasn't an intersection = true.
THEN dimension Goal is Down 1.

Rule 30 : IF Goal = Down1 ^ Down_gap hasn't a gap = true.
THEN dimension Goal is Down 2.

Rule 31 : IF type = width ^ all Goal has an intersection = true.
THEN dimension Goal is Inside.

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Rule 72 : IF type = circle.
THEN dimension Goal is Inside

Rule 73 : IF circle is in an Entity.
THEN inside_circle is true.

Rule 74 : IF inside_circle is true ^ Center 1_area is true.
THEN dimension Goal is Inside & Center 1_area.

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Conflict Resolution

Rule ordering is used for conflict resolution and to give priority through a descending system. Figure 9 shows a case of conflict resolution.

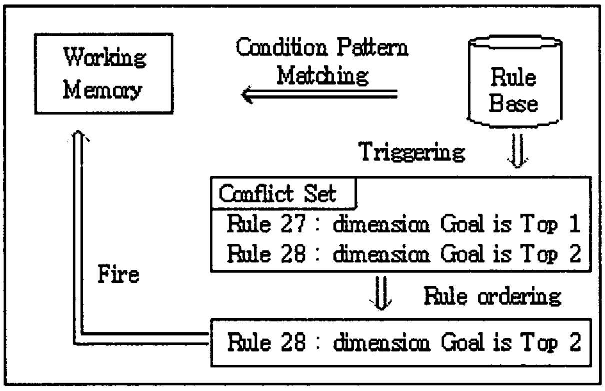

Figure 9 - Conflict resolution

Inference process

The inference process is forward-chaining. The status of condition satisfaction is classified through condition matching of the entity, sub-entity allocated to initial fact, produce sub-entity type (straight, arc, circle) and inferred facts such as Top 1, Down 1, Left 1, Right 1, Diagonal-width, Diagonal-length and finally reaches a goal. The following Figure 10 shows the inference process in the pattern of tree.

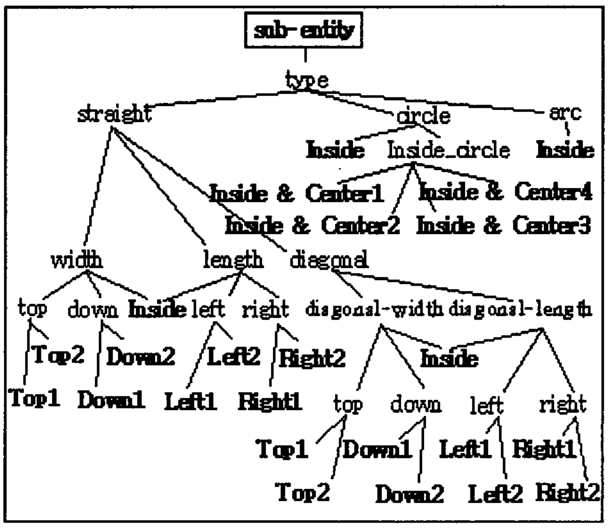

Figure 10 - Inference process

Example of application

Figures 11 and 12 are the result of an automatic production of the expert system and shows improvements with regard to the problems seen in Figures 2 and 3.

① There are indicated dimensions for horizontal line and vertical line to the diagonal line.

② Dimension lines have proper line alignment.

③ Minimized overlapping of dimension lines.

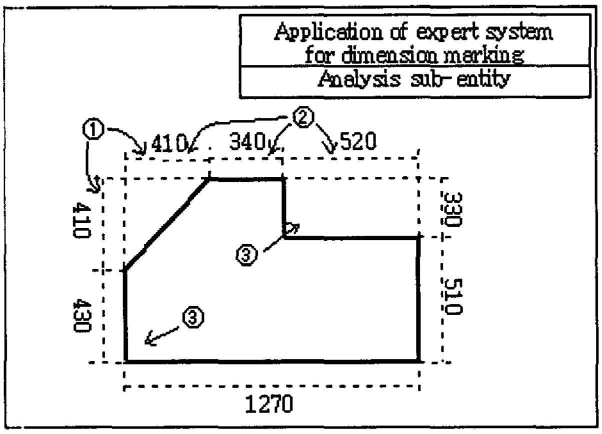

Figure 11 - Item Drawing 1 : applied expert system

④ Removed overlapping between dimension values by classifying them on Right 1 and Right 2.

⑤ Dimension indication which indicates the location of the inside circle is shown.

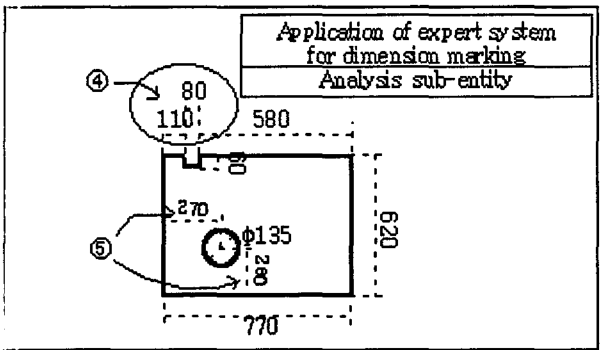

Figure 12 - Item Drawing 2 : applied expert system

Conclusion

Automatically produced drawings by GDS do not fully satisfy the standard of the general dimension marking method used among layout designers. The lack of this standard quality mainly results from the fact that the overlapping among dimension markings appears frequently. This causes frequent corrections in drawings.

In this study, to solve the overlapping problem we suggested applying the expert system to GDS. It minimized corrections in drawings and provided the expected effects of easiness of application of the new dimension marking method of design experts at the time of changing the dimension marking method.

Further, it needs more study to make the rules in detail in order to avoid the overlapping phenomenon between the grating and dimension markings in the case of extremely complex grating designs.

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