# Feature Recognition Technique from 2D Ship Model Using Fuzzy Rule

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***Abstract*—this paper presents the feature recognition technique that recognizes the feature from 2D ship drawings using fuzzy inference method. 2D ship drawings include a lot of symbols and texts. They were complicatedly combined each other. So, it is very difficult and fuzzy process to recognize the feature from 2D ship model. Fuzzy inference method is suitable to solve these problems. Input information for fuzzy inference is connection type of drawing elements and properties of element. Output value is the correspondence between target feature and candidate feature. The recognition rule is the fuzzy rule that has been predefined by designer. In this study, the Midship section drawing of general cargo ship was used to verifying suggested methodology.**

## I. Introduction

In the initial stage of ship design, the concept of product is embodied and function, arrangement and simple feature of product are defined. And the best-optimized design plan is confirmed through the inspection of scheme. This process has to be accomplished rapidly. But design knowledge is poor in this stage. Therefore, 2D drawings are usually used in this stage. However, ship drawings in the detail stage are represented as 3D model. Because that it makes possible to check the interference of parts, analyze the structural safety and the hydrodynamic performance etc. Currently, the processes that transform 2D model into 3D model are performed by designers. But many problems have been occurred in this process such as the delay of design time, the omission of parts information, and the mistake of input etc.
Therefore, the automatic transform technique that transforms the 2D model into the 3D model is required.

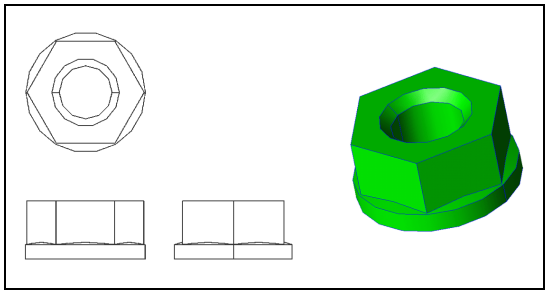

Fig.1 3D Reconstruction from the projection plane

There are mainly two kinds of method to transform 2D model into 3D model. One is to transform 2D model into 3D model using the analysis of projection view. Fig.1 is the example of 3D reconstruction using the analysis of projection view. The other is to transform 2D model into 3D model using the feature recognition. Fig.2 is the example of 3D reconstruction using feature recognition. Over the past few decades, some studies have been made on 3D model reconstruction from 2D model. Idesawa and others have been studied the method of projection view analysis. [1] Aldefeld, Dori and others have been studied the method of feature recognition. [3] Especially, Shin applied the feature

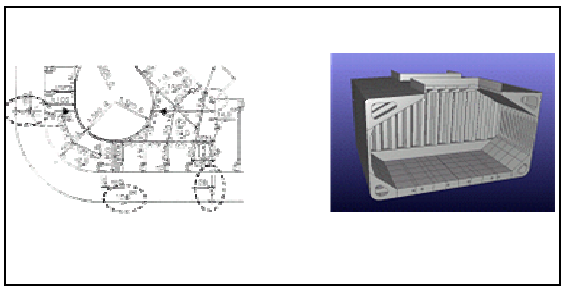

Fig.2 3D Reconstruction from the projection plane

recognition method into the ship design. He used the recognition rule such as Table 1 to recognize the feature of 2D ship drawing.

However, '10% inclined', '50% inclined', 1st UP' and others are crisp value. If the feature properties are fuzzy and have some range, this recognition rule cannot recognize the ship feature. Consequently, the recognition range of this method is small.

Table 1. The Recognition Rule of Ship Design Feature

| FEATURE | H -LOCATION | V -LOCATION | LENGTH | DIRECTION |
|---|---|---|---|---|
| DECK | 1st UP | LEFT | LONGEST | 10% INCLINED |
| SSHELL | 1st DOWN | LEFT | LONGEST | VERTICAL |
| BOTTOM | 1st DOWN | LEFT | LONGEST | HORIZONTAL |
| IN-BOTTOM | 2nd DOWN | LEFT | LONGEST | HORIZONTAL |
| GIRDER | DOWN | LEFT | | VERTICAL |
| TTOP | 2nd UP | LEFT | | 50% INCLINED |
| SLANT | DOWN | LEFT | | 50% INCLINED |

Therefore, we introduced Fuzzy Inference Method to overcome these problems. A first step of automatic transformation technique is to recognize the part feature from 2D ship model. In this study, the ship part features are automatically recognized from 2D model using Fuzzy Inference Method. 2D drawings include a lot of symbol, text and its representation is very fuzzy and various. So far, Fuzzy Inference Method is suitable for recognition of 2D feature from 2D model.

## II. Fuzzy Theory

Fuzzy set theory was introduced by Zadeh [8] as a means of representing and manipulation data that was not precise, but rather fuzzy. Fuzzy set theory has been applied to complex systems that are difficult to define precisely. It is suitable in defining the ambiguous relationship between the system inputs and the desired system outputs.

Let $X$ be a universal set and $x$ be an element. A fuzzy set $A$ in $X$ can be represented as: $A = \{(x, \mu_A(x)) \mid \forall x \in X\}$ . $\mu_A(x)$ is a membership function that assigns to each $x$ a membership grade in the unit interval [0,1]. Operation on fuzzy sets is to generate a new membership function. Let $A$, $B$ and $C$ be fuzzy sets in $X$ with the membership functions $\mu_A(x)$, $\mu_B(x)$ and $\mu_C(x)$ respectively.

Union: $A \cup B = C$ if $\mu_C(x) = \mu_A(x) \vee \mu_B(x), \forall x \in X$ (1)

Intersection: $A \cap B = C$ if $\mu_C(x) = \mu_A(x) \wedge \mu_B(x), \forall x \in X$ (2)

A fuzzy model is composed of fuzzy implications and its output is inferred by a fuzzy reasoning algorithm. According to the form of consequence in fuzzy implication, fuzzy reasoning is classified in three types: Tsukamoto fuzzy model, Mamdani fuzzy model and Sugeno fuzzy model. In this paper, we use Mamdani [9] fuzzy model.

## III. Methodology

Fig.3 shows the whole process of feature recognition

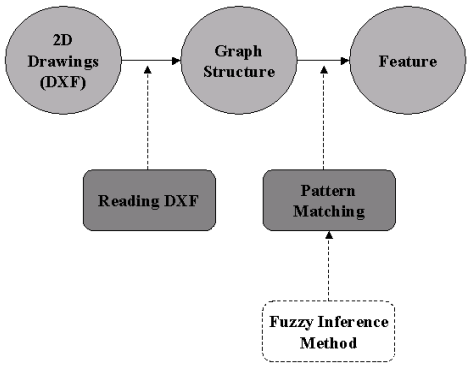


Fig. 3 Feature Recognition Framework

First, it read entity from 2D drawings. Secondly, it constructs Graph structure based on read entity. Finally, it finds target feature on constructed Graph structure using Fuzzy inference method and Graph matching algorithm.

### *A. Read Entity from 2D drawings*

In this study, the input drawings format is DXF(Data eXchange Format) file format. For the feature recognition system has wide use, the input drawing format has to be shared data structure between different CAD systems. DXF file format was suggested AutoDesk Co. for sharing drawing information in 1982. Now, most of CAD system support DXF file format. In particular, CADRA and AutoCAD system that are utilized in shipyard support DXF file. DXF file is divided into six sections. They are HEADER, CLASSES, BLOCKS, TABLES, OBJECT and ENTITIES. Through the division of sections, user can get easily desired information from DXF file. Table 1 shows the function of each section. [2]

Table. 1. Sections of DXF file format.

| Section Name | Description |
|---|---|
| HEADER | It includes general information of drawing. Creation date, version… |
| TABLE | It includes table information. Line type, layer |
| BLOCK | It includes the information of block. |
| ENTITY | It includes the information of Entity. Line, Arc, Spline… |

Among the six sections, only ENTITIES section contains geometric information. So, feature information is extracted from this section. In this study, DIME(Dxf Import, Manipulation, and Export library) used for reading DXF file. DIME is a C++ class library for reading, constructing, manipulating, and writing DXF file data. The function of DIME follows.[10]

- loading DXF files into a dime object hierarchy containing the DXF data
- building dime object hierarchies from scratch
- extracting geometry data from dime object hierarchies
- manipulating dime object hierarchies
- traversing the dime object hierarchies while performing various tasks
- saving dime object hierarchies as files conforming to the DXF file format

### *B. Filtering of input data*

Generally, drawing composed of a number entity. A Drawing of Midship section includes about 3000 ~ 4000 entity. If all entities are read into memory, recognition process become very complex and calculation performance is deteriorated. In this

study, it solved this problem using Filtering Process. Filtering criterion can be color of entity, layer information, and line type etc.

In the drawing of Midship section, a longitudinal part and a transverse part are drawn together. However, these parts are classified by color information. In the drawing that was used this study, longitudinal parts are drawn red color and transverse parts are drawn white color. Fig. 4 is a drawing of Midship section before filtering, Fig. 5 is a drawing of Midship section after filtering, that is longitudinal parts. Before filtering, the number of entity is 828. After filtering, the number of entity is 88. Amount of processing data decreased over 80%.

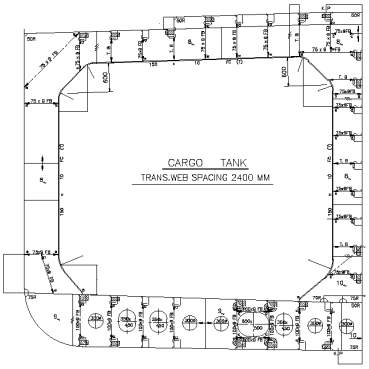


Fig. 4 Midship section before filtering

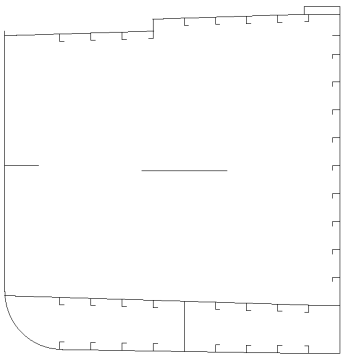

Fig. 5 Midship section After filtering

*C. Construction of Graph Structure*

Feature is an assembly of basic entity. For example, Fig .6 shows a Lightening Hole of ship. This composed of two Line entities and two Arc entities. Accordingly, the relation of entities must be considered for feature recognition as well as property of entity. Although same Arc entities, that could be the one of Bilge or the one of Lightening Hole. Therefore, Entities that were filtered are constructed as an upper level data structure. The data structure has to include the property of entity and the relation of entities. In this study, Graph data structure used for upper level data structure. [3][5][7]

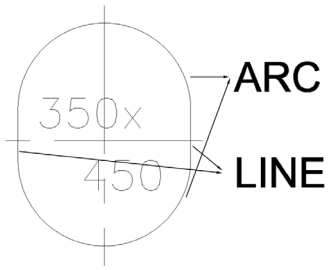


Fig. 6 Lightening Hole

Graph data structure composed of Vertices and Edges. The properties of entity are saved Vertex. The Relation of entities is saved Edge. The properties of entity are Length, Angle, Point, and Color etc. The relations of entities are the type of connection, the angle of connection etc. The properties of entities are extracted from DXF file. The relations of entities are computed through the intersection algorithm. Fig. 7 shows the information which stored in Graph data structure.

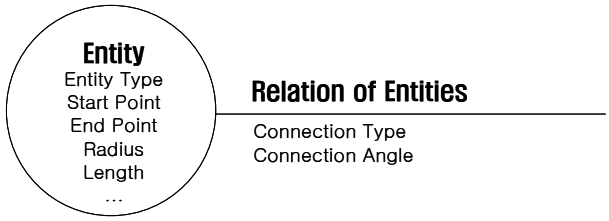


Fig. 7 The information of Graph data structure

*D. Feature recognition using fuzzy inference method.*

The feature recognition is achieved by graph matching algorithm and fuzzy inference method. First, select a candidate sub-graph on the whole graph structure. Fig.8 shows this process.

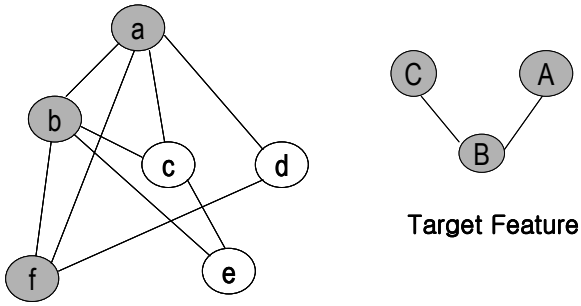


Fig. 8 Selection of candidate sub-graph

Secondly, evaluate a score of candidate sub-graph through the fuzzy inference method. Input valuables of fuzzy inference module are the properties of entities and the relations of entities. This is extracted from graph data structure. The evaluation function is a fuzzy rule for feature recognition. Fuzzy rule is predefined by user. Fig. 9 shows the process of score evaluation. Fig. 10 shows the fuzzy rule for feature recognition.

And, repeat this process continuously. Finally, sub-graph that gets a best score is confirmed as the desired feature.

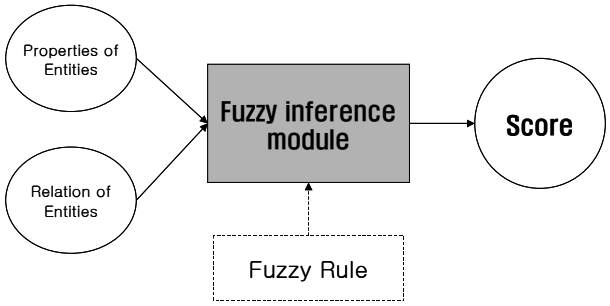


Fig. 9 Evaluation of Score

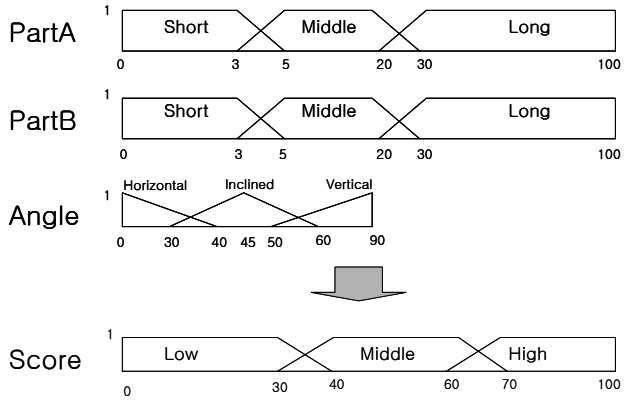


Fig. 10 Fuzzy Rule for recognition

## IV. Application Result

In this section, we present a set of examples to illustrate and verify the suggested method. We experimented to recognize Bottom Plate, Side Plate, Inner Bottom Plate, and Longitudinal Stiffener from the midship section drawing of Cargo Tanker using suggested method. They are all longitudinal parts. The recognition method that Shin suggested can recognize Bottom, Side, and Inner Bottom Plate but can't Longitudinal Stiffener. The method of this study can recognize all of Bottom, Side, Inner Bottom Plate and Longitudinal Stiffener. Fig. 4 is the drawing which used in this study.

The first step of feature recognition is to read DXF file of midship section. The drawing that used in this study includes 828 entities totally. (Fig 4) Table 2 shows all entities. Table 3 shows the number of entities after filtering. It is only 88 entities. Filtering criterion is color information of parts. In this study, we recognized only longitudinal parts. Longitudinal parts have red color on the midship drawing. Therefore red color entities were extracted in the filtering process and the amount of data processing decreased over 80%. It improves not processing performance but recognizing performance.

Table 2 The number of Entities Before Filtering

| Entity | The Number |
|---|---|
| Line | 434 |
| Arc | 150 |
| Circle | 5 |
| Point | 7 |
| Solid | 81 |
| Dimension | 20 |
| Text | 131 |
| Total | 828 |

Table 3 The number of Entities After Filtering

| Entity | The Number |
|---|---|
| Line | 86 |
| Arc | 1 |
| Total | 87 |

Next step is to construct filtered entities to graph data structure. We used STL(Standard Template Library) to construct graph data structure. Properties of entity such as start point, end point and entity type etc saved into vertex of graph data structure and relation of entities such as connection type and connection angle saved into edge. Relation information was computed by intersection algorithm.[1] we made Line-Line intersection and Line-Arc intersection algorithm. Because the number of all entities is 87, the repetition times of intersection algorithm was $87^2$-87=7482. If it was not filtering process, the repetition times would $828^2$-828=684756.

Fig. 11 shows the features that are recognized in this study. The bottom plate, inner bottom plate and side plate are represented a line entity on the midship drawing. So, Length, inclined angle and vertical position of them were used to recognize them. However, the longitudinal stiffener is represented the combined figure of two lines. Therefore Lengths and connection angle of two lines are used to recognize them.

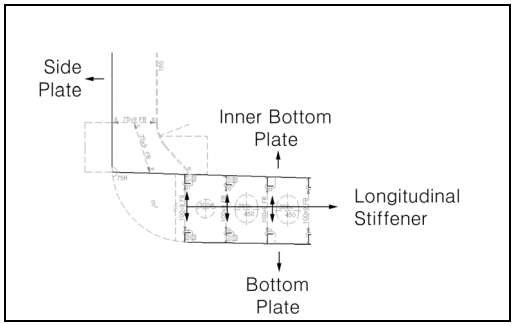


Fig. 11 Features of midship section

*A. Recognition of Bottom Plate*

Table 4 shows the result of Bottom Plate recognition. Input valuables of fuzzy inference are a length of a part, an angle of a part, and a horizontal position of a part on whole drawing. The horizontal position of center on drawing is zero. Maximum score is 81.5(part 3). Therefore, part 3 was recognized as Bottom Plate.

Table 4 Result of Bottom plate recognition

| Part | Length (mm) | Angle (degree) | Horizontal Position (mm) | Score |
|---|---|---|---|---|
| 1 | 500 | 0 | 2709 | 18.3 |
| 2 | 1000 | 90 | 3459 | 14.2 |
| 3 | 5418 | 90 | -1331 | 15.8 |
| 4 | 1042 | 90 | 230 | 13.3 |
| 5 | 5319 | 0.88 | -199 | 81.15 |
| 6 | 4922 | 34.8 | -379 | 37 |

*B. Recognition of Longitudinal Stiffener*

Table 5 shows the result of Longitudinal Stiffener recognition. Input valuables of fuzzy inference are lengths of two parts, an angle between two parts. Maximum score is 83.9(part 3). Therefore, part 3 was recognized as Longitudinal Stiffener

Table 5 Result of Longitudinal Stiffener recognition

| Part | Length1 (mm) | Angle (degree) | Length2 (mm) | Score |
|---|---|---|---|---|
| 1 | 500 | 90 | 1000 | 18.3 |
| 2 | 5418 | 88.1 | 3116 | 18.7 |
| 3 | 250 | 90 | 90 | 83.9 |
| 4 | 150 | 88.2 | 6503 | 15.1 |
| 5 | 150 | 0.88 | 90 | 15.3 |

**Conclusions**

From this study, the following conclusions were obtained:

1. Introduced the fuzzy theory in the part of feature recognition, a recognition range was enlarged.
2. This study presents basic method for transforming 2D model into 3D model
3. The method of this study can be applied a different field.

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