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Computer-Aided Design Data Extraction Approach to Identify Product Information

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Abstract: Problem statement: Many approaches have been proposed in previous such as AUTOFEAT algorithm, feature recognition, Intelligent Feature Recognition Methodology (IFRM), a part recognition algorithm and graph theory-based approach in order to solve the integration issue between CAD and CAM. However, there is no direct connection from CAD database and machine database. Therefore, comparison among the approaches has been conducted because to recognize the suitable approach is the importance tasks before this research can be proceed for the next stage. **Approach:** This study focused on CAD data extraction approach to identify product information. CAD data referred as Computer-Aided Design (CAD) data extracted from the CAD drawing which contained the drawing of product that be produce by manufacturing. CAD data consisted of geometric and non-geometric data. Geometric data contained lines, curves and vertex. While non-geometric data include texts, colors and layers. The extracted CAD data were needed to generate the product information which is useful information for the machine in production field to produce the product for the manufacturing same as depicted in the CAD drawing. Basically, the product information consisted of product details such as length, thickness, wideness and radius of the product, processes information for the machine to process the product such as taper, cutting, drilling and punching. In addition, product information also contained type of materials for the product. **Results:** As a result, feature recognition is the most suitable approach can be applied for this research. Thus, the approach was selected to precede the next stage. **Conclusion:** Conclusion from the comparison among the approaches is in term of accuracy of extracted data is not accurate when the drawing is incomplete drawing or contains the noise such as unwanted lines or any shapes cross the object in the drawing.

Key words: CAD data, extraction, product information, feature recognition

INTRODUCTION

In CAD/CAM application machine directly depend on product information to produce the product. Thus, extraction is the important key to produce the correct product information. However, not all CAD drawing can be extracted. There is a certain situation where CAD drawing cannot be extracted because of noise and incomplete drawing. Thus, this study will recognize the suitable approach from comparison among previous approaches to solve the problem.

AUTOFEAT algorithm to extract the geometry and non-geometry information from CAD drawing has been proposed by Prabhu *et al*.[1]. The proposed algorithm solves the problem on how to extract non-geometry information and how to organize the extracted geometry and non-geometry information inside the database. According to Nafis *et al*.[2], among the non-geometry information in CAD drawing are dimensions, text and labels. The research tested the proposed algorithm on CAD drawings, where the algorithm shows that it is capable in extracting geometry and non-geometry information and all of the information is stored inside a structured database.

According[2,4,7,8,10], no communication between low level data with a high level data is a problem to integrate the CAD application and CAM application. Low level data is a CAD data such as lines, points, curves and circles. While high level data is machine data which is involved processes and planning. The

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approach succeeded in managing the solid CAD data and links it to the manufacturing process plan. Huang *et al*.[3], a CAD drawing contains original geometrical information of graphical primitives. The goal is to make the pre-process task more accurate. However, to increase the accuracy, CAD data need to be extracted. For this reason, the research has proposed Graph Theory-Based Approach.

Based on the highlighted approaches, there are still a lot of extraction approaches that have been proposed by previous researchers. The data extracted from the CAD drawings will be used to make planning process, time scheduling and producing products. Finally, finding from this study is the suitable approach to generate the product information.

Application: Basically, the purpose of automatic extraction is to reduce the human errors during read a CAD data was motivated many development of CAD/CAM application system. In manufacturing, to increase the productivity of production and reduce the production cost was motivated programmer to develop the manufacturing system. The technique how the system extract CAD data is same with the expert techniques extract CAD data from the CAD drawing. Extraction is needed to extract CAD data from CAD drawing and present it in product information for machine process. Extraction is applied to extract lines, arcs, circles, text and boundaries of the object inside the drawing. All extracted information will be recognized and stored into a structured database.

Usually extraction has applied in manufacturing system. Example, the manufacture wants to produce bolt and nut. The information about the bolt and nut has depicted by the designer in the CAD drawing. To get the information about the bolt and nut such as length, radius and thickness the manufacturing need to extract the data from the drawing. When the product information have been produced, then only the machine can do the process to produce the bolt and nut same as depicted inside the drawing.

Aim to produce an automatic application of extraction the boundary of shoes pattern. Lai *et al*.[6] has been produced the Automatic shoe-pattern boundary extraction by image-processing techniques. The purpose is to generate shoes boundary information for cutting machine to cut material into shoes pattern shape same as depicted in the drawing.

Based on objective to reduce time-consuming and exhaustive task to extract CAD information from CAD files, Huang *et al*.[3] was proposed an approach and produced an automatic recognition of CAD data from CAD drawing. The proposed approach focused on extract the building plan information. According to Huang *et al*.[3], the importance information during extract the building plan is recognizing the openings and enclosure on the plan usually represented as the doors.

The automatic extraction of manufacturing assembly information from 3D CAD model is an issue that motivates Mahmut Gulesin *et al*.[4] to propose an approach and try to solve the issue. Sometime designer had drawn the part drawing is the subset from the assembly drawing in the CAD drawing. Part drawing is the part from assembly drawing which is drawn more details by the designer. Usually part drawing is scale drawing from the assembly drawing. Moreover, part drawing contains the processes information such as cutting, punching and drilling. In other words, part drawings were contributed into process planning in the CAD/CAM system. Figure 2 shows for graphical view.

Currently application issue that relate with this research is extraction from 2D CAD manufacturing drawing and want to generate the product information for machine from the extracted 2D CAD data. However, before can proceed to the next stage, first step is needed to recognize the suitable approach or algorithm that can be used for development purpose. Have many CAD/CAM approaches had been proposed in previous for the same reason is to extract the CAD data. Extraction and comparison among previous approaches will discuss detail in topic extraction process and comparative. The final outcome from this extraction approaches is product information for machine to process the product.

Data extraction: Data will be used for this research is CAD data from the CAD manufacturing drawing. CAD drawing has a several file format. Generally have 3 types of CAD file format usually used for the extraction purpose. Some researchers attempt to used Data Exchange Format (DXF), Initial Graphic Exchange Specification (IGES) or Standard for the Exchange of Product model (STEP)[9]. Even though different file format but there still used the same basic CAD structure. HEADER section, TABLES section, BLOCKS section, ENTITIES section and END of FILE are the basic structure of CAD file. Detail explanation about basic structure of CAD file will discuss in topic extraction process.

Generally before the CAD data can be extracted by the extractor, CAD drawing will be input into the system. Then, loader will load and read CAD drawing through the CAD structure as shown in Fig. 3. Loader in the system will check the drawing whether the drawing in the correct format or not. In current

situation, when the loader fail to load the drawing into the system, then the drawing will not continue for the next process (extraction process). Rapid solution has been taken to solve the issue with develop the pre-template for the loader. The purpose is easy for the loader recognizes and read the structure of the CAD drawing in term of the location of the object, part and tables in the CAD drawing. Afterwards, CAD drawing can proceed to the extraction process.

MATERIALS AND METHODS

Extraction process:

CAD language: Recently, there are lot versions of CAD, where different versions of CAD use different structure of database to store the drawing information. Before further explanation about CAD language, this study will explain about CAD/CAM fundamental. Usually, designers illustrate his ideas on study and draw the detailed drawing on CAD system. Afterwards, an expert person will extract and translate the drawing detail into product information. If the expert extracts the wrong information from the drawing, the wrong product will be produced. This contributes to the main reason for researchers try to produce the most accurate extraction method to extract information correctly. Figure 1 shows the fundamentals of CAD/CAM.

Basically, CAD language contains lines, arcs and circles to create an object. As stated on topic of data extraction, basic structure of CAD file contains sections namely HEADER, TABLES, BLOCKS, ENTITIES and END of FILE. Usually HEADER section contains settings of variables connected with drawing [**Error! Reference source not found.**]. Other variables set the units used to measure angles, defaults for chamfering, offsets and scaling. The TABLES section contains several lists of information used in the rest of the drawing, such as the list of line types, layer names, fonts and preset views of the drawing. Next, the BLOCKS section contains predefined drawing elements that might be present in the drawing. For example, a block could define a standard door knob that is placed on every door in a drawing. Block definitions are referenced in the ENTITIES section with the INSERT command. Furthermore, the ENTITIES section contains the actual object data of the drawing. This can include raw data such as line, arc and circle entities as well as INSERT commands that place a predefined block definition at a certain position in the drawing. At the end of the CAD data is marked with an END of FILE directive placed at the last line of the file. All CAD data from BLOCKS section until END of FILE will extracts to generate the product information. An example shown in Fig. 3, product information contains the detail of the product same as depicted inside the drawing. As shown in Fig. 3, product information generally consists of product name, material, part name, part no., processes, product checked, product approved and product model. In advanced, product information is the high-level data for the machine to process and produce the product.

Extraction process: Extraction process is a process to extract CAD data in order to obtain product details and processes which contributes in a production of the product[1]. Basically, CAD data contains geometrics and non-geometrics data. Geometrics data is a subset of the object depicted in the drawing which contains lines,

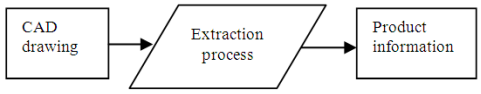

Fig. 1: CAD/CAM fundamental

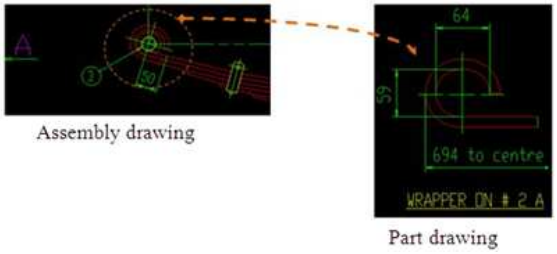

Fig. 2: Example of assembly and part drawing

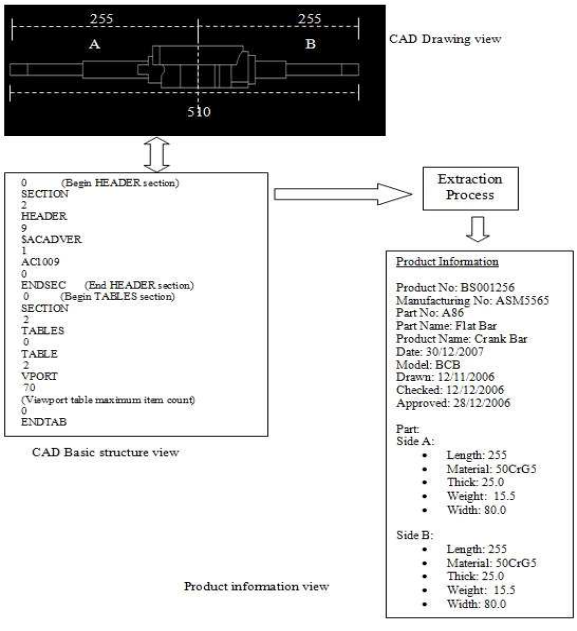

Fig. 3: Example of CAD data extraction process

arcs and circles. Otherwise, the non-geometrics data is related with an attribute of the object such as length, thickness, radius, diameter and label. The geometrics and non-geometrics data are closely connected to produce product information[1].

Before the extraction process start, CAD drawing will be input into the CAD/CAM application system. Loader in the system loads and read the drawing. Then, the extraction process will be started and extract the CAD data from the drawing. All extracted CAD data will be recognized and stored into structured database. The structured data will be present in a structured view as product information as shown in Fig. 3.

Basically, the CAD data have been extracted by the extractor is data inside the tables such as name of product, date, type of materials, product number, length, thickness, width and manufacturing number. Furthermore, data from the objects such as dimensions of the object, type of the objects such as lines, arcs, circles and symbols. In order to get a clearer view this study will focus more detail and make a comparison of the highlighted approaches. By the way, extraction process cannot extract the data when loader fails to load the CAD file.

Extraction approaches: The approach had been proposed by Prabhu *et al*.[1] is focusing to extract geometric and non-geometric data from the CAD drawing. The situation that motivates the proposal of the algorithm is the lack of ability of the previous extraction algorithm in extracting and representing non-geometric attributes. According to Prabhu *et al*.[1], non-geometric information is related to processes and tooling information for producing a product. The algorithm was developed by Prabhu *et al*.[1] based on solid CAD drawing. DXF and IGES file format were the input for the algorithm, where the input will be arranged into appropriate data structures to aid later processing. Afterwards, the drawing data will be split into two distinct classes of loops based on their coordinate connectivity. Further, all the data are categorized into clear views of the drawing. Next step is the pattern analyzer where in this stage; the algorithm will check the structural relationships between the geometric data and converts it into unique string patterns. The algorithm will associate the non-geometric data and geometric tolerances and interpret it intelligently. The final stage will integrate all the recognized information and represent it into an object oriented feature based format.

Feature Recognition approach has been proposed to create a connection between CAD and Computer-Aided Process Planning (CAPP)[2,4,7,8,10]. This approach focused to generate the process plan. Before the process plan can be produce, the system need to recognize the processes involve to producing the product. The technique used by the Feature Recognition to recognize the processes has involve in producing the product is recognizing the features of the object such as holes and step. Then, the data will be referred into the processes library of the system such as punching, cutting, stamping and drilling. Next step is mapping process between object and the processes. Arrangement of the processes flow to produce the product would be the last step before process information will be produce. Process information will be produced by the approach in order for machine generates the product.

According to Huang *et al*.[3] CAD data is very hard to utilize directly into the architecture information. To solve this problem, Graph Theory-Based Approach has been proposed. The aim is to extract CAD data inside a building from architecture plans. The initial step of the approach is to correct the geometrical errors and remove useless elements that do not have any relation with CAD data such as decorative symbols, dimension and annotated information and specification notes. Next, the approach will recognize all the openings that refer as doorways or passages. Final step of the approach will convert the architecture plan into a graph. The benefit of the approach is the approach can identify all the enclosures inside a building and obtain their geometrical information and relationship in the architecture plan.

Based on Adem and Mahmut[4], CAD database is not suitable to be used directly in CAM system. For that reason he proposed a Part Recognition Algorithm. The approach uses STEP file format as an input. The aim of this study is to develop of a suitable representation in terms of topological and geometrical data as input to part recognition algorithm and to recognize the parts designed in a CAD drawing through an expert system. The approach can be used in manufacturing activities such as Group Technology (GT) and process planning.

Intelligent Feature Recognition Methodology (IFRM)[5] has been developed to create a standard structure can be used for all CAD packages. This approach that was proposed by [5] uses IGES file format as input and as standard file format. This approach consists of 3 main phases (1) a data file converter, (2) an object form feature classifier and (3) a manufacturing feature classifier. The initial step is converting CAD data into a proposed object-oriented data structure. Feature recognition program is used to extract the geometry information. Before extraction process Boundary Representation (B-Rep) technique is used to recognize the boundary of the objects. Then, the geometric features will be classified into different

feature groups. In the last stage, the approach will map the extracted features to a process planning. This approach has increased the ability in providing a good generic representation of a simple product data.

As a conclusion, each approach had been developed to solve and handle the specific situation and issue. Even though have many approaches, still do not have one extraction approach that can handle various problems and situation of issues. Lack communication between CAD and CAM is the main issue in CAD/CAM application.

RESULTS

Comparative: Testing has been conducted based on conceptual testing using the highlighted approaches which is have been discussed in the previous topic. The testing have used of 100 2D mechanical CAD drawings. The drawing was in DXF file format. The measuring used in that testing is the tested approaches must be able to extract all the geometrics and non-geometrics data. Furthermore, the approach should be able to extract the noise drawing.

Figure 4 shown the result on the extraction of geometrics and non-geometrics data the AUTOFEAT algorithm can extract the geometrics and non-geometrics data efficiently. Focusing to extract the non-geometrics information the approach does not have any problem to extract non-geometrics data. However, the approach focused on solid 3D CAD drawing. Otherwise, the Feature Recognition method has a weakness where it cannot extract non-geometrics information although it is very successful in extracting geometrics information. The Graph Theory-Based Approach only focuses on the architecture of CAD drawing. The approach can extract the dimensions, but only needs the architecture plan drawing, the dimensions are deemed useless and thus removed. However, the advantage of this approach is that it can extract the CAD drawing even if the drawing has noise.

Part recognition algorithm successfully extracts 60 from 100 drawing. The approach can extract the geometrics and non-geometrics information but it still has a limitation of the assembly information of product. Even though the last method, Intelligent Feature Recognition Methodology (IFRM) focused on solid model, the methodology actually uses the B-Rep technique and Feature Recognition for extraction process.

Figure 5 shows the testing result on the extraction of drawing with noises. Examples of drawings with noise are drawings with incomplete geometrics, unknown symbols and incorrect drawing formats.

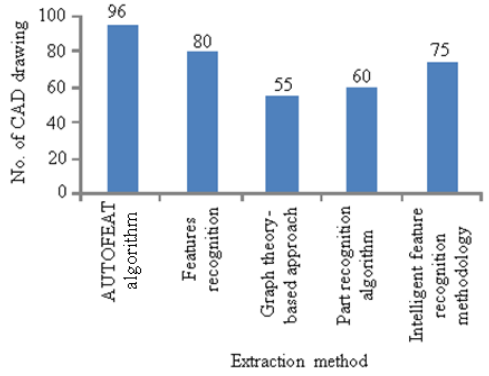

Fig. 4: Testing result on extraction of geometrics and non-geometrics information

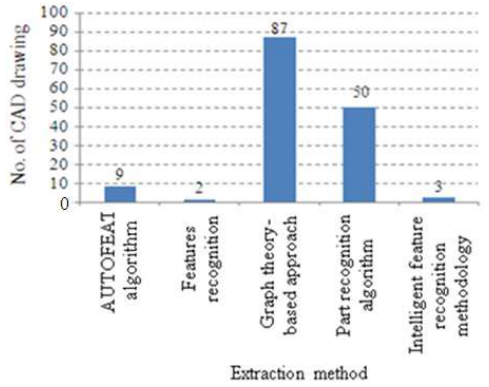

Fig. 5: Testing result on extraction of noise CAD drawing

In Fig. 5, AUTOFEAT algorithm is only able to extract 9 out of 100 drawing. This is because the researcher of this method assumes all the drawing to be extracted must be clear from the errors. The same situation is reflected in the Features Recognition method and was produced the lowest extraction result of drawings with noise. The approach is capable to extract 2 out of 100 drawings. However, the Graph Theory-Based Approach was able to efficiently extract 87 out of 100 drawing. This approach took drafting errors seriously and for that reason the author developed the technique to read the drafting errors. As a result, the accurate information is able to be obtained after the extraction process.

The second highest result in Fig. 5 is the Part Recognition algorithm where it uses the FORM technique for the extraction process. Furthermore, FORM technique will list out all the information gathered from the drawing. The algorithm will use the embedded expert system to recognize the object. In addition, the algorithm will integrate all the information into assembly model. The conclusion from both results,

Features Recognition is a good approach in extract the geometric data. But, the approach fails to extract the non-geometric data. Moreover the approach also fails to extract data from the noise drawing.

DISCUSSION

Extraction process cannot extract the data when loader fails to load the CAD file is a first extraction problem. This situation happen may be because the system does not have pre-defined or initial templates for the CAD drawing will be upload into it. This situation can be avoid by using the pre-define format of the CAD drawing.

Lack of communication between CAD and CAM is the main issue in CAD/CAM application. Feature recognition based approach main purpose is to create a link between CAD and CAPP, but before the link is created, the approach need to recognize the features of CAD data and CAPP data. Extract the geometric data and recognize it use the geometric information in the library is the technique to recognize the features of CAD data. However, there still have lacking during extraction process, where the feature recognition based cannot extract the non-geometrics data. Feature recognition also fails to extract data from the noise drawing. In addition, feature recognition based approach still lack of the knowledge about the CAD data when the drawing is 2D CAD drawing.

CONCLUSION

Based on this research, the main problem of the CAD drawing extraction is identified. The difficulty for feature recognition based to manage between low-level 2D CAD data with machine processes data because feature based lack of knowledge about the 2D CAD data and CAPP data. Furthermore, unstructured the feature recognition database make the process to generate product information become difficult. Based on the comparative result, feature recognition based is the most suitable and related with this research. According to the problem had identified, enhancement of feature recognition based will be proposed for the next step in this research. This proposed idea will be designed and tested on the next stage in this research.

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REFERENCES

1. Prabhu, B.S., S. Biswas and S.S. Pande, 2001. Intelligent system for extraction of product data from CADD models. Comput. Ind., 44: 79-95. http://portal.acm.org/citation.cfm?id=371506
2. Nafis Ahmad and A.F.M. Anwarul Haque, 2001. Manufacturing feature recognition of parts using DXF files. Proceeding of the 4th International Conference on Mechanical Engineering, Dec. 26-28, Dhaka, Bangladesh, pp: 111-115. http://203.208.166.84/nafis/paper2.pdf
3. Huang, H.C., S.M. Lo, G.S. Zhi and R.K.K. Yuen, 2008. Graph theory-based approach for automatic recognition of CAD data. Eng. Appli. Artifi. Intelli., 21: 1073-1079. http://portal.acm.org/citation.cfm?id=1435070
4. Adem, C. and M Gülesin, 2007. A part recognition based computer aided assembly system. Comput. Ind., 58: 733-746. http://portal.acm.org/citation.cfm?id=1293639
5. Emad S. Abouel Nasr and Ali K. Kamrani, 2006. A new methodology for extracting manufacturing feature from CAD system. Comput. Ind. Eng., 51: 389-415. http://portal.acm.org/citation.cfm?id=1221951
6. Lai, M.Y. and L.L. Wang, 2008. Automatic shoe-pattern boundary extraction by image-processing techniques. Robot. Comput. Integrat. Manufact., 24: 217-227. http://portal.acm.org/citation.cfm?id=1322877
7. Napsiah,I. and A.B. Nooh, 1997. Boundary representation-based feature recognition. J. Technol., 26: 65-74.
8. Rameshbabu, V. and M.S. Shunmugam, 2009. Hybrid feature recognition method for setup planning from STEP AP-203. Robot. Comput. Integrat. Manufact., 25: 393-408. http://portal.acm.org/citation.cfm?id=1465778
9. Safe Software Inc., 1998-2006. Autodesk AutoCAD DWG/DXF reader/writer. Autodesk, Inc. http://docs.safe.com/fme/html/ReadersWriters/dwg.htm
10. Zhou, X., Y. Qiu, G. Hua, H. Wang and X. Ruan, 2007. A feasible approach to the integration of CAD and CAPP. Comput. Aided Des., 39: 324-338. http://portal.acm.org/citation.cfm?id=1238376