Graph Based Method for Lathe Machining Part Model

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Abstract. Process planning is about bridging design to manufacturing in an effective way. Although many methods can be used to recognize CAD and manufacturing feature, one way to do it is by Graph-based Method. Attributed Adjacency Graph (AAG) is develop for each feature of a part model in this case to ease of planning the machining of the part. Each machining feature will have a unique constructive sub-graph (CG). This paper proposes CG for lathe machining feature. The proposed CG is useful for future development of a generative process planning system of a lathe machining.

1. Introduction
The terminology of process planning is very vague [1] and no standard definition or general understanding is adopted of what is included or not, or for any of the measures. Hence, the process planner performs the desired role not only to define the process plan but also to transfer the support of manufacturing knowledge to ambitious product design [2]. Process planning includes the functions and activities for planning a series of detailed procedures and instructions for producing a part. Diverse sorts of optimization methods are utilized by diverse authors for the process parameters’ optimization [3]. As a key contributor to the area of Computer Aided Manufacturing (CAM), Computer Aided Process Planning (CAPP) has been perceived with substantial significance on the part quantities, quality, devaluation in manufacturing cost and time, while minimize manual interference [4][5]. Despite the broad literature, feature introduction has not been actualized essentially in real industrial activities [6]. Feature acknowledgment rules have been defined to identify various protrusion and depressive features such as bends, beads, arrows, holes, which occur in panels of metal [7].

2. Related Works
Graph-based method is first developed by Chen and Tsai [8]. This method introduced a new way in recognizing CAD features by connecting features such as face, line and vertex together. The connection represent a graph and it is defined as attribute adjacency graph (AAG) concept. With similar pattern of AAG, CAD feature such as hole, pocket, chamfer and fillet can be recognized. This method is then evolved and being used by many other researchers. Simplification of part model features had been introduced by this method in [9] in order to reduce the complexity of the part model. Reducing complexity lead to reducing the part model size and application to define the machining can be done
[10]. Beside isolated features, graph-based method is being applied for intersecting features for milling machining features [11]. Moreover, graph-based method is applied to rotational part model [12].

3. Methodology
The cylindrical product planning process is mapped and known based on the use of feature recognition and the feature mapping process after the design process using SolidWorks software. This paper, starting from the SolidWorks process, goes through a design procedure to determine the cylinder design according to the highest and longest product diameter.

The part model of the case study is shown in figure 1. Figure 2 shows the flowchart of the process for the recognition. Feature recognition by Solidworks will define features of the CAD models. With the development of the AAG of the manufacturing features, recognition from Solidworks can be compare and verified. The defined AAG will be collected and algorithm in choosing the required machining features will be assign in a developed algorithm. This paper will demonstrate lathe machining features of turning, chamfering, grooving, drilling and tapering.

![Figure 1](image1.png)

**Figure 1.** The part model for the case study.

With the recognition of the machining features, these features can then be mapped into the right sequence and assigning the necessary tool. A sample of part model that consist of lathe machining features will be demonstrated as a case study in this paper. This part model is then been used to be machine by real lathe machine with the sequences proposed. Table 1 shows the type of tools that can be assign to specific machining features. In order to map the desire sequence, turning, chamfering and tapering can be assigned with the same tool. Therefore, in order to achieve less machining time, these machining processes can be assigned at the early step after facing process is done. The next process will require the tool to be change. Because of parting process will be the last, and it can be using the same tool with grooving, therefore grooving process will be the second last. The final sequence will be as follow, 1) facing, 2) turning, 3) tapering, 4) chamfering, 5) knurling, 6) threading, 7) drilling, 8) grooving, and 9) parting.

To arrange a process sequence on a lathe, a graphical method is a method used in this paper. Generally, this method is suitable for studying minimalist image representation because the graphical method is a discrete and mathematically simple representation. In order to identify the sequence based on the form equation and its consequences, this method is applied so that this paper can create a new procedure for machining a lathe based on what this paper will first start. Based on the design modality, the generalization of the product, the domain process and the last one is to develop a graphic-based method and then a sequence of cylindrical products will be generated based on the sampling distribution.

The lathe machining process refers to a process sequence that has been identified by a graphical method. The sequence of the lathe machining process based on the graphical method is identified based on the differences and similarities in each process.
Figure 2. Flow chart of the process.

Pseudocode for the process planning
Find face of CAD part model, Fi (i=1,2,……,n), edges, Ei(I = 1,2,……,n)
for Fi =1, search adjacent face
for Ei =1, search adjacent edges
    Develop AAGi for each feature
End for Fi
End for Ei
Next process

3.1 Attribute Adjacencies Graph for machining features
In order to develop the AAG of the case study, each face has to be classified. The classifications will be based on the face type. It is either planar, conical or cylindrical. Planar face will be classified as P, conical as N and cylindrical as C. The part model of the case study has twelve faces and it is classified as figure 3.

Figure 3. The classification of the faces of part model
### Table 1. Tooling specifications

| Type of cutting tools used | Angle of the cutting tools | Speed of cut (rpm) |
|----------------------------|----------------------------|--------------------|
| Turning                    | 0                          | 870                |
| Grooving                   | 0                          | 125                |
| Drilling                   | 0                          | 125                |
| Tapering                   | 20                         | 125                |
| Chamfering                 | 20                         | 125                |
| Knurling                   | 0                          | 60                 |
| Threading                  | 0                          | 60                 |

### Table 2. AAG for lathe machining features.

| AAG        | Machining Features |
|------------|--------------------|
| ![Turning](image1) | Turning           |
| ![Tapering](image2) | Tapering          |
| ![Grooving](image3) | Grooving          |
| ![Facing](image4) | Facing            |

"AAG for lathe machining features."
To differentiate these faces combinations into manufacturing feature, the same concept as defined in [8] is adopted. Concave edges will be defined as 1 and convex edges as 0. The AAG for lathe machining features are defined as Table 2.

4. Result and discussion

Workpiece designs at SolidWorks will experience feature introduction by Feature Works. By using Feature Works for feature recognition, feature recognition can be categorized based on two things, namely interactive methods and automatic methods. Automatic feature recognition requires no user intervention. The feature mapping works to match terms in SolidWorks with terms on lathes.

Table 3. Feature Mapping Result.

| Term in SolidWorks | Term in lathe machine |
|--------------------|-----------------------|
| Hole               | Drilling              |
| Chamfer            | Chamfering            |
| Imported1          | Turning               |
|                    | Tapering              |
|                    | Grooving              |

4.1 Lathe Machining Process

The process was started from turning process; face turning and parallel turning to get the actual dimension of the cylindrical product. The speed used for face turning is 870 rpm. After that, the drilling process took place. The drilling process requires different types of cutting tools and cylinder block positions. Next, the grooving process. The grooving process uses a slower speed because only a small portion of the cylinder block undergoes this process. Next, the tapering process. The cutting tool needs to be changed from different angles. After the knurling process, there is a small cutting process called chamfering. Chamfering is a process that turns the edges of each 90° edge into quarter circles so these cylindrical beams are harmless to anyone. This thesis is continued with the knurling and threading process. The two processes also undergo a one-sided cutting flow only to obtain a fine, sharp thread. The total requirement for these 2 processes is less than 30 minutes. Further research can also use other machines such as milling machines to conduct research using the same method, namely the graphic method so that the correctness of this method can be identified and accounted for perfectly.

5. Conclusions

From the research that has been done, the purpose of this paper has been fulfilled, because this paper proposes a new sequence of lathe machining processes by adapting a graphic method to select a machining sequence that can optimize the lathe machining process. With the AAG specified in Table 2, it can be a useful guide in finding the algorithms and properties of the lathe machining process.

6. References

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