GTL S43-b – CLIPS Project

Methods, models and tools for integration: Manufacturing process, Product modeling, Process planning, Manufacturing resources

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This work can be performed in team of two students. The deliverables (one file per step and a file containing your comment and your answer of the last step) have to be zipped and mailed before the **20th October 18:00** to alain.etienne@ensam.eu. Several documents can help you: they are stored in the SharePoint website.

The aim of this project is to build an expert system with CLIPS software, which generates the draft of the process plan by considering setups (gathering of features) and their precedence links. Based on this process plan draft, the second main goal is to detail this skeleton by generating machining operations.

Step 1: Description of part to machine

The first step aims to gather machining features regarding their machining directions. To do so, the first set of rules has to be able to identify what are the machining orientations of a feature considering the machining operations able to perform it and the machine available in the company.

In this project, only three types of features are considered to describe parts to analyze: holes, plans and slots(/pockets). By using CLIPS template, define these features, with these parameters:

- Hole :
  - Name (SYMBOL)
  - Diameter (FLOAT)
  - Depth (FLOAT)
  - Through (TRUE or FALSE)
  - Orientation
- Plan :
  - Name (SYMBOL)
  - Length (FLOAT)
  - Width (FLOAT)
  - Orientation
- Slot/Pocket :
  - Name (SYMBOL)
  - Length (FLOAT)
  - Height (FLOAT)
  - Width (FLOAT)
  - Through (TRUE or FALSE)
  - Bottom (ROUND or SQUARE)
  - Orientation

The orientation is described by a set of integers (vector of integers). These parameters can be enriched if you consider it mandatory.

	Plane	Hole	Slot/Pocket
Plane	Contact Perpendicular	-	-
Hole	Start in Lead to	Coaxial Cross	Start in Lead to
Slot / Pocket	Start in	-	-

Figure 1 : Relationships considered in this project

In addition of this description of intrinsic parameters of features, we want to know what are the topological relationships linking features. In this project, the topological relationships considered are proposed in Figure 1.

In order to check if the template is ok, you can instantiate all feature types. To do so, add to fact base (by using an `Initial-Fact` Rule of `Deffacts` function) the features describing the part of Figure 2. For the part in right of the figure, you can find several key dimensions in the article available in S43-b website. You can interpolate all the remaining parameters.

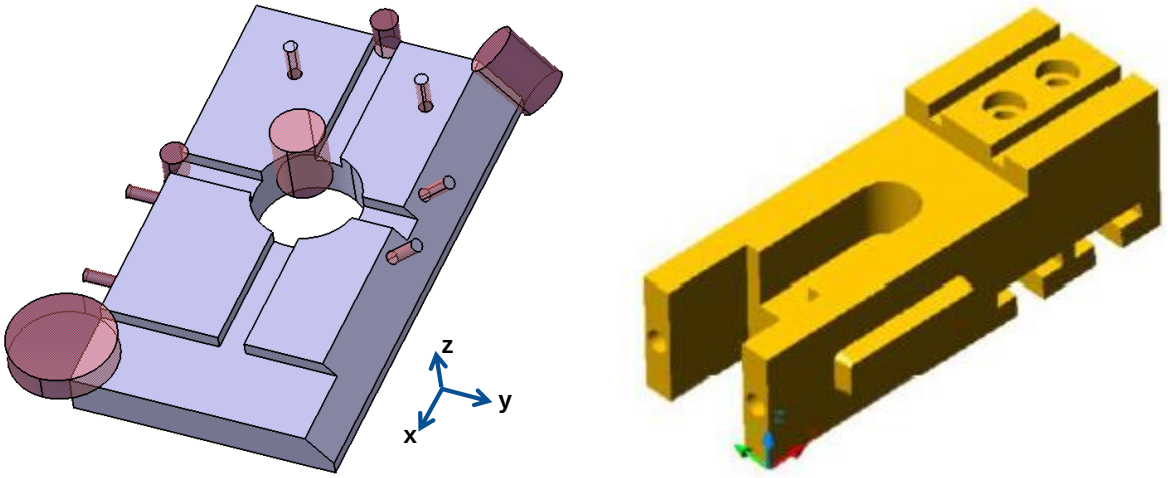

Figure 2 : Parts to instantiate into CLIPS program (article available in the SharePoint website)

Step 2: Identifying the machining directions:

In order to identify how to machine features, expert rules are needed. Several examples of this kind of rules are available in the bullets above. All information is expressed: the conditions and the resulting machining direction. By using the `DefRule` instruction in CLIPS, express these example rules and perform one inference run to see what are the results of this inference.

- If the feature is a hole:
  - The direction of machining is its orientation.
  - This direction is not exclusive when the hole starts in one feature and in the same time leads to another one. In this case 2 machining directions are possible (the orientation of the hole and its opposite vector).
- Several machining directions can be used to machine plans without interaction with other plans:
  - The machining direction is normal to the plan (face milling)
  - All directions coplanar to this plan (side milling)
- If two (or more) plans are perpendicular, the machining direction selected is the one normal to the one having the biggest surface.
- If two plans are in contact, these plans are machined separately and their machining directions are normal to each plan (face milling)
- If the slot/pocket is through the material and its bottom is rounded, then it is possible to use two machining directions (the one normal to the bottom of the slot/pocket or the one normal to its longest side). In the other cases, the machining direction is the normal to the bottom of the slot/pocket.

Step 3: Considering the tools

The aim of this section is to take into account the geometry of the cutting tools in the machining operation selection. Several rules are expressed and stored in the table Figure 3. Complete or

improve the previous CLIPS rules in order to take into account the management (and so these new constraints) of machining operation and tools.

Type of feature	Conditions on its parameters	Machining operation	Feature resulting	Constraints on tools
Hole	Not Through Length/Diameter >=2	Deep Drilling	Raw material (feature removal)	Diameter of tool = diameter of hole Length tool > length feature
	Not Through	Drilling		
	Through	Drilling		
	Through	Milling	Feature diameter reduced by 2 mm	Diameter of tool < (diameter of hole - 4) Length tool > length feature
Plan	-	Face Milling	Raw material (feature removal)	If one other plan is perpendicular, the tool length has to be higher than the width of this plane
		Side Milling	Raw material (feature removal)	Length of the tool has to be compatible with the machined plane
Pocket	Through			

Figure 3: Machining expert rule to implement into CLIPS

Add as facts, several tools to check the behavior of your expert system. Do not hesitate, after several runs to prioritize some rules by increasing their salience.

Step 4: Features gathering into machining sub-phases

This step aims to gather all features into sub-phases regarding their machining directions. In this step we consider that the machines available are all 4-axis machines.

Add a CLIPS rule (or a set of rules) in order to perform this gathering. Find a way to check that all directions belong to the same plan (this is the condition to perform all machine directions in only one set-up).

Step 5: Ordering

In order to identify what are the gathering to machine before the others, new rules are proposed in order to identify the machining order of feature composing the sub-phases.

- If one hole crosses one other, the shortest diameter has to be machined first
- If two plans are in contact (or in perpendicular contact) the one having the biggest surface has to be performed last.
- If a hole or a slot/pocket starts on a plan, the plan has to be machined first. This rule is also true if a pocket or a slot start in a plane, or if a hole start in a slot/pocket.

In addition to the ordering of sub-phases, generate the final machining process (that's to say order the machining of feature into the ordered sub-phases) and display it.

Step 6: Conclusions about the performance of this approach

As a conclusion of this project, you have to propose as a synthesis of the pros and cons of using Expert Systems, based on your experience of this approach (and not the synthesis proposed in the course).