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WORKFLOW BASED PROCESS MODELING FOR OPTICAL COORDINATE MEASUREMENT

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Abstract – This paper presents in detail the relevance and the potential of a novel approach for process modeling in creation of fixed sequences of various measurement steps using optical coordinate measurement devices.

Keywords: process modeling, workflow, coordinate measuring devices

1. INTRODUCTION

In general image processing is getting more important every day. Industrial image processing in particular is continuously spreading to a wider spectrum of application. This results in considerable implications for the operation of software tools used for this kind of tasks. One of the main jobs associated with coordinate measurement devices is the creation of fixed macro sequences and their execution [Fig. 1].

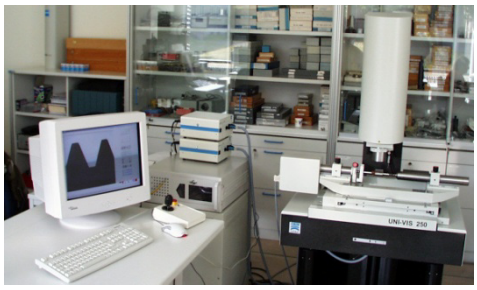

Fig.1 Example for a coordinate measuring machine, the UNI-VIS 250

In research and development as well as education the advantages and disadvantages of certain control concepts for machines become obvious due to the high number of people operating the device. Considering this fact a versatile model should be preferred which is capable of covering different aspects. Probably the most important criterion when choosing a model are the different levels of knowledge the potential users posses. An expert user might want to input most settings manually whereas less experienced operators need a suitable environment that does not ask too much of the user. In addition to that there are fixed orders that need to be followed in certain situations like machine initialization, novice users are not necessarily familiar with such standard procedures. A new model needs to combine solutions for both of these contradicting paradigms. The possible ways of representation for a sequence are also of great significance. Most forms of data can be presented in textual form as it is commonly found in today systems, but manual input of complex data requires sophisticated knowledge about custom language syntax. A graphical representation of a sequence of steps in measurement would greatly enhance user interaction and usability of the system. A toolbox of single step tasks that are required for coordinate measurement combined with a graphical user interface, which also includes relations and interdependencies of these steps, would allow novice users to benefit from a knowledge base already integrated into the systems itself. Additionally this abstract form of process modeling allows for sequence programming without the use of a physical machine even when used by inexperienced personal.

2. STATE OF THE ART

Processing measurement tasks requires settings for various parameters. First of all the machine itself must be initialized which usually is done as a fixed routine specific to the machine type. Afterwards additional parameters need to be set to reasonable values that basically depend on the object that is to be tested. In order to achieve a high quality edge signal among others the direction and intensity of lighting as well as the focus position need to be adjusted. These settings are not necessarily fixed throughout the whole measurement process. It is more likely that they need to be adapted when testing a different region of the object or even an entirely different object. There are numerous possibilities for variation requiring complex knowledge about the relations between different parameters. Only after deliberately setting these parameters the user can expect to achieve accurate measurement results for geometric features of the object. Therefore in each measurement process model specific values or strategies to find such values need to be included ensuring that the relevant parameters are set in their correct chronological order [1].
Today's software packages mostly rely on the user's own knowledge for such prerequisites, they are not implemented by the process model itself. Due to the form of those models

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such routine procedures cannot even be copied from previous models since they are far from self-explanatory.

3. CONCEPT OF PROCESS MODELING FOR MEASUREMENT TASK SEQUENCES

In software commonly used today fixed sequences are created using one of the two following methods. The first approach is a teach-in-mode which allows the user to manually perform the sequence step by step once while a software component records every detail on the way. The second possible way is manual input of each single step by writing a series of commands in a textual script using some kind of abstract macro language syntax.
In both cases the process model is stored as a chain of commands usually hardly readable to users that are not highly experienced with this particular software product [Fig. 2].

```
BK Definition of a Line-AOI;
#P -900.0 @ 200.0 @ 0.0 @ 1;
#P -600.0 @ 200.0 @ 0.0 @ 1;
#50.0;
#50.0;
#3;
UPI;
SIS 3 @ 1;
CID;
#>I1;
KIWS;
CID;
DKI 255 @ 0 @ 0;
```

Fig.2 Codeexample of measuring sequence [2]

As a result most users lack the ability to edit such a model after creation which often leads to problems when reusability is concerned. In command based scripts there is hardly a way to present relations to the user. When trying to remove, insert or alter a part of the model/script expert knowledge about the implied dependencies is required. Ignorance of these relations can easily cause the model to become useless. A new modeling technique would need to enable the user to edit a sequence of tasks after it was created without expecting expert knowledge of him.

4. DEFINITON OF A NEW MODEL

The novel approach proposed in this paper is the workflow based process model for measurement [3] [4].
Representing the process of measurement as a workflow has significant advantages for the user especially concerning guidance, support and comfort. This method can enable the user to create and modify task sequences in an easy and ergonomically more suitable way. The key elements of measurement process models based on this principle are states and activities. These items are represented in an integrated graphical user interface where their alignment can be used to visualize parameters and their relations. Fixed relations can also be included as a set of rules that the model designer will implement. This visual design paradigm allows even inexperienced users to modify and reuse previously created models while following the rules that are comprehendible due to their graphic representation.
Flow charts and state charts are used for visualization of these workflows whereas their appearance can be defined individually for each user, model or sub model. This principal allows for a hierarchical composition of the process encapsulating sub models for reuse in other higher level process models. Routine procedures like machine initialization even for different kinds of machines can easily be created and integrated into complex task sequences. In optical coordinate measurement this poses a considerable advantage since a typical measurement procedure consists of many similar smaller tasks. Exchanging system dependent parts of a procedure for reuse of the model on a different system also becomes very easy.

5. EXPLANATION BY EXAMPLE

The figures 3 to 5 show an example of process modeling done with the Microsoft® Workflow Foundation.

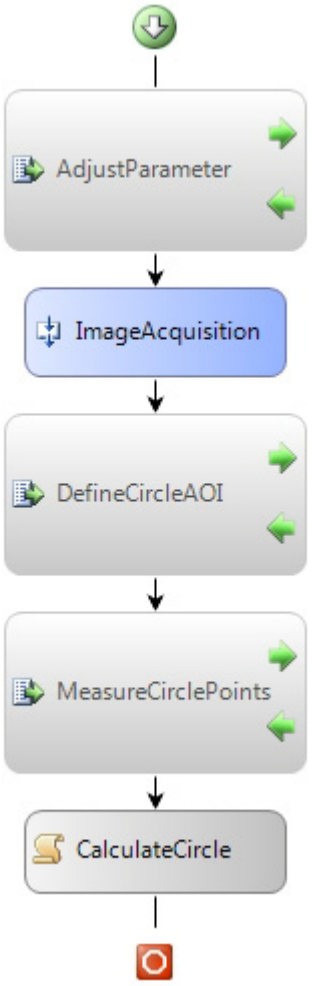

Fig.3 Example for measurement workflow, using Microsoft® Windows Workflow Foundation

They represent different levels of abstraction for the process of measuring a circular structure. The top level view of the procedure consists of an adjustment of system parameters, the acquisition of the image that is to be evaluated, the definition of an area of interest and the measurement itself. Since this is mostly a sequential chain of activities the operation was modeled as a synchronous process.
Figure 4 is a visualization of the next stage of decomposition for the top level activity 'MeasureCirclePoints'. It comprises a loop in which the atomic step of calculation of the area of interest is performed followed by the abstract procedure of measurement for a single point.

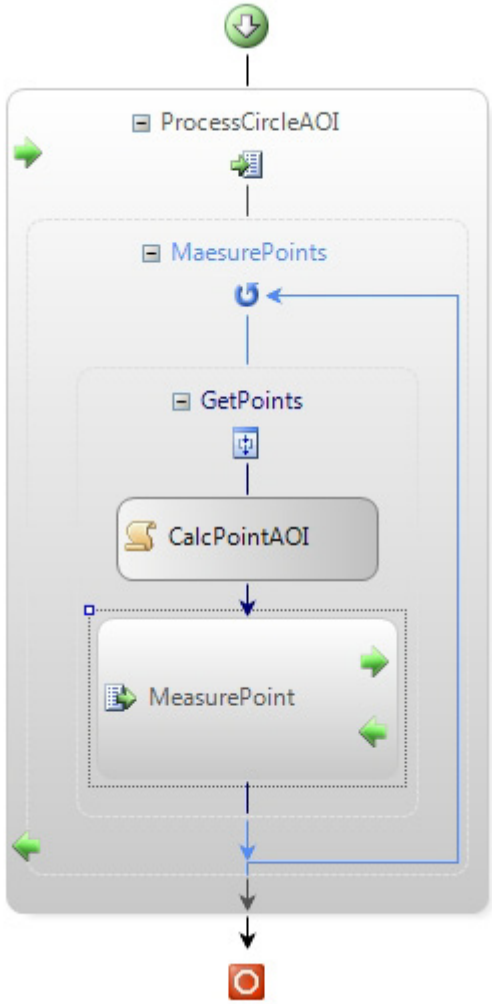

Fig.4 Example for workflow – MeasureCirclePoints

This example demonstrates the reusability since the lower level process of the actual measurement of a circular contour can be integrated in other process models without the additional operations included in the top level model.
The next lower level of abstraction for this part of the overall process is the measurement of a single contour point, which again is modeled as a sub-process and visualized in figure 5. It only consists of atomic operations and therefore cannot be decomposed any further.

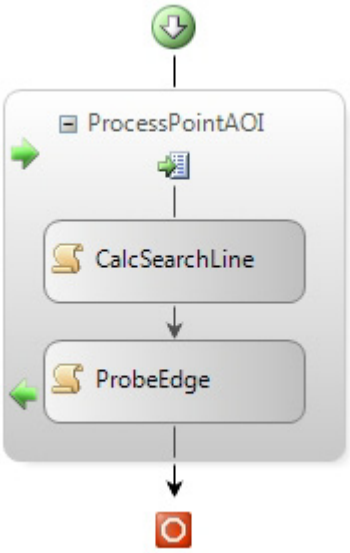

Fig.5 Example for workflow – MeasurePoint

Visualizations of the remaining sub-models have been omitted to enhance clarity. The call 'AdjustParameter' performs automatic or manual adaption of system parameters – depending on the sub-model used. The 'DefineCircleAOI' operation is to return an area of interest, which can be input manually or defined by some automatic mechanism – again depending on the detail model.

6. USABILITY

Workflow based process modeling requires a graphical user interface. To the user this is a great advantage over a scripting language based on abstract syntax. Using a visual designer for creation and modification of such task sequences can improve clarity and readability of a model. Additionally a workflow based measurement process modeling technique allows for a more effective supervision while executing the process model. This feature gets more important as the models become bigger and therefore are harder to debug. The system can be implemented to be interactive with the environment making it possible to consider multiple external sources that might influence the process. Using the graphical design technique of this approach makes it easier for both inexperienced users and experts to operate optical coordinate measurement machines which can also lead to a more effective use of operation time.

7. CONCLUSION

Using suitable modeling techniques for creation, modification and execution of measurement tasks for optical coordinate measurement devices can make the work necessary to operate such a machine considerably easier. A workflow based process modeling system is an adequate tool. The essential difference in comparison to today's text based procedural process models is the fact that the execution of

workflows is based on events instead of a fixed series of commands.

Previous user interaction principles forced the user to manually execute every step of a measurement task sequence on the machine at least once. If something unexpected happens the model needs to be modifier or even entirely recreated depending on the user's level of knowledge. In contrast to that workflow based process modeling defines multiple sequences of tasks and deterministic relations between them. This defines the whole process from an operational point of view by modeling states and activities. In addition external influences can easily be included into the model. The workflow based approach coordinates the process by defining who does what (activity), when it is done (state and event) and how it is done (environment) rather than just defining a fixed sequence of commands.

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