State Based Application Modeling For Industrial Image Processing

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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 various measurement applications using industrial image processing and quality measurement.

Keywords: application modelling; state machine; industrial image processing

I. Introduction

In general image processing is getting more important every day [1]. 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 industrial image processing is the creation of specific machine vision applications and their execution. This causes significant consequences for the creation editing and maintenance during the application lifetime.

Measurement problems are classical engineering problems. In contrast to that implementation in a usable application is situated in the field of information technology. In research and development as well as in education the advantages and disadvantages of certain technologies for creating algorithms and applications become obvious due to the high number of people operating the system. 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 possess [2]. An expert user might want to input most settings manually whereas less experienced operators need a suitable environment that does not demand too much details of the user. In addition to that fact there are fixed orders that need to be followed in certain situations like machine initialization or image acquisition 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 dependencies and relations 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 different states 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 system itself. Additionally this abstract forms of process modeling allows graphical programming without the use of a physical machine even when it is used by inexperienced personal.

II. State Of The Art

Creating measurement applications requires knowledge about the progress on measurement procedures or 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 depends on the object that has to be measured. 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 [3]. Todays software packages mostly rely on the users own knowledge for such prerequisites, they are not implemented by the process model itself. Due to the form of those models such routine procedures cannot even be copied from previous models since they are far from self-explanatory.

III. Concept Of Process Modeling For Measurement Applications

In software development in small and medium-sized enterprises as well as in teaching and training today there is commonly used one of the following two ways of realization measurements. The first approach is to create an application for industrial image processing with powerful tools created for computer scientists which allows the operator to create and control all steps manually. The second possible way is to use existing applications, toolboxes, windows, or tools to create a measurement process. In this case, the developer is to be subject to the limitations of the used objects such as visualization, input masks, data types or formats.

In both cases the creation is complex and difficult to maintain or upgrade with an engineering education. Especially in the field of education and training there is a huge barrier to entry. Even after overcome the initial obstacles 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 work expert knowledge about the implied dependencies is required. Ignorance of these relations can easily cause the whole work 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.

IV. Definition Of A New Model

The novel approach proposed in this paper is the state based process model for industrial image processing [4], [5]. Representing the process model of measurement as a state diagram offers significant advantages for the user especially concerning guidance, support and comfort. This method can enable the user to create and modify applications for optical measurement in an easy and ergonomically more suitable way. The key elements of measurement process models base on this principle of states and conditions as expressed in the Unified Modeling Language UML [6]. According to the UML notation a state represents a situation with certain invariant conditions. These conditions can be associated with activities when entering the state, activities when leaving the state and activities during the state. The connection between two states named transition which connects directed targets with sources due to an incoming event. The transition also can be associated with activities. These items represent 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. In each state a corresponding user interface can be parameterized. This option allows an almost unlimited interaction between model and user interface to customize the user interface. This visual design paradigm allows even inexperienced users to modify and reuse previously created applications while following the rules that are comprehendible due to their graphic representation. This principle 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 industrial image processing this poses a considerable advantage since a typical measurement procedure consists of many lines of similar code. Exchanging system dependent parts of a procedure to reuse of the model on a different system also becomes very easy. The modeling of the application in states and transitions inherently results in a program that is executable, and free of semantic errors. There are no possibilities for unexpected events in the model.

V. Explanation By Example

The figures one to three show an example of application modeling done with a self-created Development Environment. They represent three different aspects for creating an application for measuring a linear structure. The first step deals with creation of a user interface. Figure 1shows a example of a simple user interface. From a selection

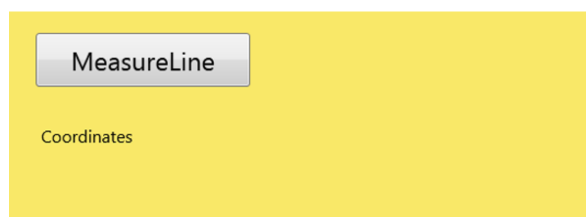

Fig. 1. Simple user interface to measure a linear structure

of visual elements the user can create and parameterize a custom user interface. The description of the surface with all its visual elements is done directly in the graphical user interface. The user doesnt need to write one line of program code.

Figure 2 is a visualization of the next stage of creating a state machine to measure a linear structure. The initial state is left due to an user interface event in the state of machine initialization. Other devices such as actuators, sensors or light sources are initialized as well. Furthermore a live image will be displayed. The subsequent state takes a snap shot after user interaction at the desired position. The systems logic freezes involved periphery on the state of creating a fixed image scene in their current states. The following state comprises the atomic step of calculation of the selected area of interest by the abstract procedure of measurement a linear structure. The

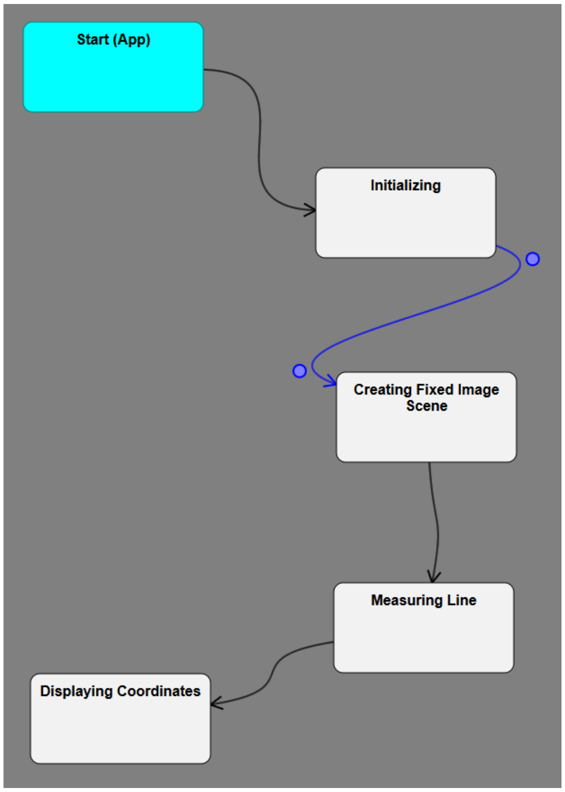

Fig. 2. State diagram to measure a linear structure

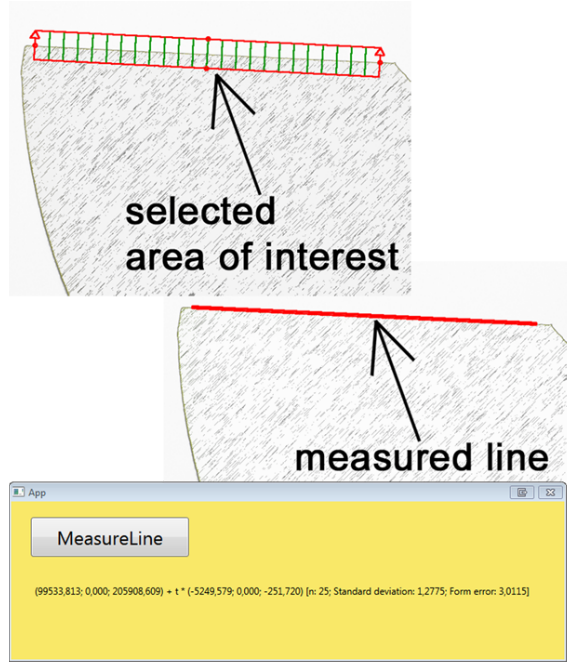

Fig. 3. Shots during the execution

measured line is the triggering event and input parameter for the transition to the state of representation on the display device. The corresponding surface element may be brought into context at the state. By double clicking on the state the application user interface is opening. In this the parameter can be assigned to a surface element which is automatically brought for display. For repetitive measurement tasks further transitions can be prepared to comprise a loop.

The last stage is the execution of the created application. A separate player runs the application. The player itself is transparent and not perceptible to the user of the running application. Figure 3 shows various steps during the execution.

VI. Usability

State based application development requires a graphical user interface. To the user, an engineer creating an industrial image processing application, this is a great advantage comparing other methods, writing lines of code or using predefined toolboxes. Using a visual designer for creation and modification a user interface and the background working state based model can improve clarity and readability of the application. Additionally a state based measurement modeling technique allows a more effective supervision while executing the process model. This feature gets more important as the model becomes bigger and therefore is 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 create industrial image applications which can also lead a more effective use of operation time.

VII. Conclusion

Using suitable modeling techniques for creation, modification and execution of specific machine vision applications can make the necessary work to develop, implement and maintain for those machines considerably easier. A state based process modeling system is an adequate tool. The essential difference in comparison to today's models is the fact that the programming itself eliminates semantic errors and almost eliminates unintentional user input during execution of the program.

Previous user interaction principles forced the user to manually execute every step of an application on the machine at least once. If something unexpected happened the model needed to be modified or even entirely recreated depending on the user's level of knowledge. In contrast to that state based process modeling defines multiple situations and deterministic relations between them. This defines the whole process from an operational point of view by modeling states and transitions. In addition external influences can easily be included into the model. The state based approach coordinates the situation by defining who does what (transition), 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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References

[1] P. Schwarzkopf, *Der Markt für Industrielle Bildverarbeitung in Deutschland*, 7th ed., Verband Deutscher Maschinen- und Anlagenbau e.V. Industrielle Bildverarbeitung, Frankfurt/Main, 2011.

[2] G. E. Thaller, *Interface Design – Die Mensch Maschine Schnittstelle gestalten*. Frankfurt/Main: Software & Support Verlag, 2002.

[3] S. Töpfer, "Automatisierte antastung für die hochauflösende Geometriemessung mit CCD-Bildsensoren," Dissertation, Technische Universität Ilmenau, Ilmenau, 2008.

[4] J. Bargenda, "Untersuchungen zur Strukturierung von Software für die optische Koordinatenmesstechnik," Project Work, Technische Universität Ilmenau, Ilmenau, 2007.

[5] J. Bargenda, "Untersuchungen zur Gestaltung und Erarbeitung von Software für die optische Koordinatenmesstechnik," Diplomarbeit, Technische Universität Ilmenau, Ilmenau, 2007.

[6] C. Kecher, *UML 2: Das umfassende Handbuch*. Bonn: Galileo Press, 2011.