Process Attribute Visualization in 3D and Virtual Reality

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Abstract. Being able to visually explore process attributes and their values supports process analysts in process understanding and optimization. The complexity of the analysis can range from a few to a variety of attributes, e.g., machining times and sensor parameter in the manufacturing domain. This paper introduces an innovative prototype to visualize process attributes within a 3D representation. The 3D representation can be displayed and explored on a monitor or a virtual reality system.

Keywords: Process Attribute Visualization, Process Model, 3D Representation, Virtual Reality

1 Introduction

More and more data from various sources such as databases, services, and real-time information is present in nowadays business processes. Incorporating as much information as available into a process seems a good thing at first. However, companies need to understand their processes to achieve their business goals. In order to support the analysis in such cases we use process models for visualization. Such visualizations often comprise a plethora of attributes, e.g., machining parameters in production processes. These attributes are crucial in understanding processes models. Various approaches e.g. views and abstractions [5, 1], where introduced to deal with processes containing multiple attributes. Usually these approaches abstract from the attribute data. These abstractions lead to a loss of information and certain relations between attributes cannot be identified anymore.

To reduce the amount of information being lost as part of the visualization process we developed a prototype called 3DViz. This prototype allows to incorporate multiple attributes within one representation by using the additional z-axis.

2 Innovations

Analyzing and understanding a business process can be a complex and overwhelming task. Some visualization approaches only show the control flow elements and hide process attributes such as time within menus. However, attributes can yield crucial information for process analysts. The most commonly

CEUR-WS.org/Vol-2420/papeDT14.pdf

visualized attribute is the *Role* attribute, however there are certainly many more relevant attributes within business processes e.g. *data elements* and *resources*. These attributes can have different manifestations, e.g., *cost*, *time* and *location*. These manifestations are not predefined; they can be different in each process model. One model uses only *cost* while another one requires a new attribute and the next model has three or more attributes. This even gets worse as those attributes might possess different data types like string or numerical values. Our prototype allows for visualizing multiple attributes within a single representation.

2.1 3D Process Visualization

We introduce a novel 3D Process Visualization prototype called 3DViz. 3DViz and an overview on the design choices are explained in the following section, details can be found in the technical report [2]. The 3DViz concepts are prototypically implemented[1]. The prototype supports the visualization of process models with multiple attributes.

3DViz allows for visualizing process models within a 3 dimensional space, hence allowing for utilizing an additional axis for process model visualization. The 3D models enable positioning of activities on the x-axis, y-axis, and z-axis and scaling of activities on these three axes. For activity positioning, 3DViz is capable of attribute visualization on y-axis and z-axis. X-axis is restricted to a processes control flow.

Currently, we support up to 5 different attributes within a process model. We could utilize more visual styles e.g., brightness, texture, and orientation to incorporate more attributes within one visualization. However, the principle of graphic economy [3] describes that up to 6 categories per variable can be discriminated. Our design choice was to utilize the styles positioning, scaling, colour, and shape. This seems to be the best trade-off between graphic economy, perceptual discriminability, and visual expressiveness.

In order to provide complexity management mechanisms we allow the user to customize the amount of attributes and the visual styles used. Numerical attribute values can be mapped to every axis for positioning and scaling. String values are restricted to positioning within swimlanes on the y-axis and z-axis.

Figure 1 depicts a sample process with 3DViz. When analyzing a process there are two important axes, the positioning axis and the scaling axis. In this example positioning axis in Fig. 1 ① depicts *Roles* as swimlanes on the z-axis and *Cost* on the y-axis. Positioning *Cost* on the y-axis leads to a visualization where activities with high costs are displayed above activities with lower costs ②. The scaling axis is visualized with colors ③. This axis shows that *Time* is scaled on the x-axis and *Data Usage* is scaled on the y-axis. ④ depicts an activity scaled on the y-axis. This activity possesses the highest amount of *Data Usage*. Additionally a room (e.g., a seminar room or an office) is created around the process model to ease navigation and orientation while exploring the model.

[1] https://bit.ly/2wTT5za

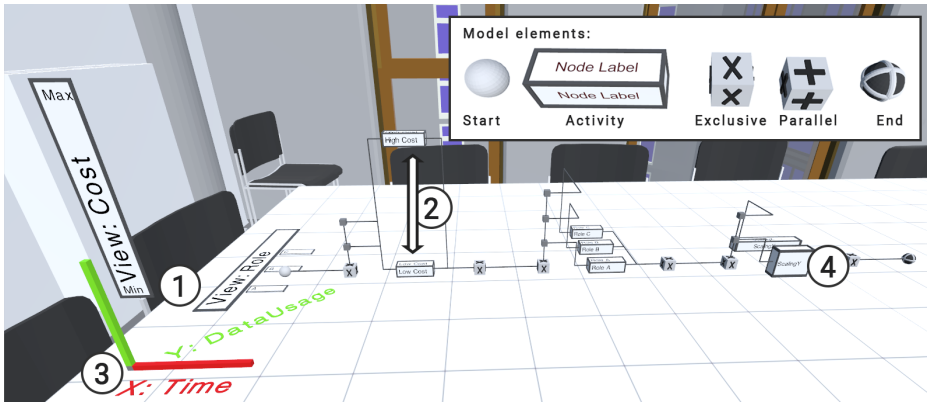

Fig. 1. Example process visualized with 3DViz.

In 3DViz, control flow elements (cf. Fig. 1) are designed similarly to their 2D counterparts in BPMN. The motivation behind this decision is to provide a familiar setup to reduce training efforts.

2.2 VR Visualization

Literature suggests that viewing a 3D model on a monitor might not be an appropriate way to transport the visual fidelity introduced by a 3D model [4]. Therefore we opted for extending 3DViz beyond monitors. We allow to view and interact with 3D models through an HTC Vive VR device.

From a visual point of view the model is represented in the same way as the 3DViz model. For this reason we want to refer to Figure 1 for a process model visualization example. The main difference is the interaction with the model. While 3DViz requires mouse and keyboard input for interactions, e.g., camera movement, the VR approach allows camera movement when the VR device is moved, i.e., moving the head forward while wearing the device will translate to movement within the virtual world.

Within 3DViz a room is created around the process model. For the VR approach the visualization of a room offers additional benefits. A room might help to avoid dizziness and disorientation when exploring the process model. In its current state the applicability of VR/AR is poor compared to Desktop systems. However, when considering the development in recent years we believe VR/AR will advance further and be better integrated in the normal day routine of people.

2.3 Visualization Configuration

In the previous sections the visualization capabilities of the prototype are briefly discussed and depicted in Figure 1. Figure 2 depicts the configuration menu. Nine

different styles for attribute visualization are available. For each style the user can select an attribute and a mapping e.g. on the z-axis the role is visualized with discrete mapping. For the attribute mapping we allow for 3 different variants, direct mapping, relative mapping and discrete mapping [2].

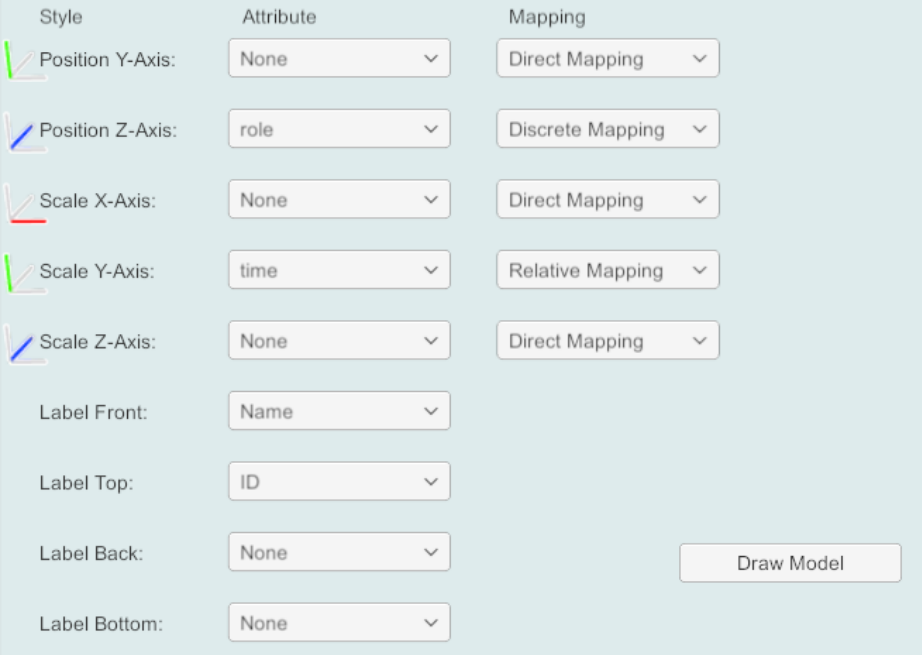

Fig. 2. Configuration of the visualization.

3 Evaluation

At an public event called "Lange Nacht der Forschung" the 3D attribute visualization was demonstrated. Based on a physical *Lego* showcase we visualized the according process instances with respect to their attributes.

Additionally we conducted a survey addressing applicability and usability of 3D visualizations. From the 42 participants 39 (92.8%) answered that 3D visualizations are useful for process model visualization. Further we asked which areas are particularly interesting when 3D visualizations are used. In total 33 (80.5%) participants answered that combining multiple attributes is an interesting field. Allowing the user to change the viewing angel an rotate around the process model was also very well received by 31 (75.6%) participants. However, to our surprise only 11 (26.8%) thought that 3D representations are particularly

useful to omit overlapping edges. More insights on survey design, demographic data, results and discussion can be found in our technical report [2].

An evaluation targeting the performance of 3DViz was conducted [2]. The data ranged from simple graphs 2 *Activities* and 1 *Control-Flow-Element* element till large graphs with 1024 *Activities* and 512 *Control-Flow-Elements*. We saw a linear growth in time needed to draw graphs. This is a very good result as large graphs e.g. 1024 *Activities* and 512 *Control-Flow-Elements* only take 2.2 seconds for drawing. In all our examples we used 5 attributes to be visualized. For the creation of these models we used a random process model creation tool [2]. This tool can be used to create large process models for demo visualizations.

4 Conclusion and Outlook

3DViz offers an innovative approach to visualize process models and their attributes. Attributes can be visualized by scaling or positioning of nodes. Scaling and positioning on the x-axis, y-axis and z-axis allows to incorporated multiple attributes within one visualization. Integrating multiple attributes leads to faster recognition of associations between attributes.

We are currently working on expanding 3DViz capabilities towards mining and monitoring. Further we want to explore the visualization of multiple processes in combination with constraint visualization.

The prototype, a tutorial, a short video and further information is available on our website[3].

Acknowledgment This work has been funded by the Vienna Science and Technology Fund (WWTF) through project ICT15-072.

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[2] http://gruppe.wst.univie.ac.at/ gallm6/ProzessGenerator/
[3] https://bit.ly/2wTT5za