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Towards verification of storyboards

End Node of a (sub-) graph defines the final target point of a legal graph traversing. *Edges* denote transitions between nodes. There are two rules to leave a node by an outgoing edge: (1) The outgoing edge must have the same color as the incoming edge by which the node was reached and (2) If there is a condition specified as the edge's key attribute, this condition has to be met for leaving the node by this edge. *Key attributes of nodes* specify application driven information, which is necessary for all nodes of the same type, e.g. actors and locations. *Key attributes of edges* specify conditions, which have to be true for continuing traversing on this edge. *Free attributes* may specify whatever the storyboard author wants the user to know: didactic intentions, useful methods, necessary equipment, and so on.

In fact, the storyboard is a hierarchically organized media that holds didactic knowledge. Because of being semi-formal it is a firm base for processing, evaluating and refining this knowledge.

In *Microsoft Visio* (Walker and Eaton, 2003), so called hyperlinks can be defined on any graph object to open either a local file of any media type with the appropriate tool or to open the standard browser with a specified URL or mail tool if it is an e-mail address. They appear as a related symbol when the mouse is located at a related node. On a left mouse-key click, the list of hyperlinks shows up. We make use of this opportunity for the *Scenes* and *Episodes*. This way, the off-line and on-line teaching materials and tools (like e-learning systems, e.g.) are collected and individually structured according to individual paths of users through the storyboard. Furthermore, a double click behavior can be defined. We make use of it for jumping into the related sub-graph, when double-clicking an Episode and for jumping (back) from a sub-graph to a related mark (reference node) behind the associated Episode in its super-graph.

Generally, the fact that there are "humans in the loop" makes processes non-deterministic, not computable, and stochastic. Therefore, modeling such processes rises the need to anticipate alternatives. Consequently, a storyboard can be traversed in different manners according to (1) users' interests, objectives, and desires, (2) didactic preferences, (3) the sequence of nodes (and other storyboards) visited before (i.e. according to the educational history), (4) available resources (like time, money, equipment to present material, and so on) and (5) other application driven circumstances.

Towards Verification of Storyboards

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Abstract

Storyboards are commonly known as rows of pictures, which exemplarily sketch scenes in performing arts. The rows specify the sequence of scenes. The scenes themselves are illustrated. Here, we adapt this term for a different more abstract and more formal use of modeling processes with humans involved like teaching, e.g. Storyboards anticipate alternative paths by a nested hierarchy graphs instead of linear lists. Generally, the concept is able to model every process performed by humans and (partially) realized by human activities (in some cases with usage of computer implemented parts). Our storyboards consist of formal elements such as scenes, episodes, edges, and references along with a "grammar" to compose these elements. Here, we introduce a concept to prove formal properties that indicate structural integrity. The implementation of this concept automatically identifies structural anomalies and helps the storyboard author to compose storyboards.

Our Concept of Storyboarding

Our storyboard concept (Jantke and Knauf 2005) (Knauf and Jantke 2006) is built upon standard concepts which enjoy (1)*clarity* by providing a high-level modeling approach, (2) *simplicity*, which enables everybody to become a storyboard author, and (3) *visual appearance* as graphs.

A storyboard is a nested hierarchy of directed graphs with annotated nodes and annotated edges. Nodes are scenes or episodes. Scenes denote leaves of the nesting hierarchy. Episodes denote a sub-graph. Additionally, there is exactly one Start- and End- node to each (sub-) graph. Edges specify transitions between nodes. They may be single-color or bi-color. Nodes and edges have (pre-defined) key attributes and may have free attributes.

Scenes denote a non-decomposable learning activity, which can be implemented in any way. It can be the presentation of a (media) document, opening of any tool that supports learning (e.g., an URL and/or an e-learning system) or an informal activity description. There is no formalism at and below the scene level. *Episodes* are defined by their sub-graph. *Graphs are* interpreted by the paths, on which they can be *traversed*. The *Start Node* of a (sub-) graph defines the starting point of a legal graph traversing. The

Checked Anomalies over Storyboards

To ensure consistency and completeness of our storyboards, we developed and implemented several verification procedures:

1. A Start-/End Node Test checks the existence of a unique entry- and exit point of each (of the nested) graph(s). This feature is important for implementing Knowledge Engineering technologies such as the one in (Boeck 2007).

2. An Episode-Hierarchy - Test checks the references between Episodes and their related sub-graphs. In particular, it checks, whether there is (1) a unique sub-graph behind each Episode and (2) a unique Episode Node for each non top-level graph as the re-entry point to the related super-graph.

3. Also, the reachability of (1) each node from the Start Node of the top level graph and (2) the top level End Node from each node any any graph is checked.

4. Furthermore, completeness and non-contradictoriness of alternative outgoing edges (with the same beginning color) is checked by logically analyzing each node's outgoing with the same start color. Of course, "dead ends" of a color will be uncovered as well.

5. Additionally, the complete storyboard is checked for nodes, which carry identical content (and can be joined by introducing a new incoming/outgoing condition color) and edges, which define identical node transitions (and can be joined as well).

Since the first test is trivial, we start describing the above tests beginning with the second one.

Summary and Outlook

Here, we focused the verification issue for storyboards. By implementing several tests, which check a storyboard's structural integrity, we provided a useful help for storyboard authors to compose legal and appropriate storyboards.

In particular, we introduced and implemented (1) an *episode hierarchy test*, which checks the tree structure of the graph hierarchy, (2) a *reachability test*, which checks, whether all nodes of a graph are reachable from the start node and from all nodes the end node of the graph is reachable, (3) a so called *color test*, which checks the logical completeness of the dependencies of outgoing edges from the incoming edges, and, finally (4) a *multiple nodes test* and a *multiple edges test* to avoid duplications of identical content in a storyboard.

Discovering these logical anomalies is very helpful for composing a storyboard. An author, who's attention is directed to such anomalies, is inspired to think about these issues and to "repair" this inconsistency.

Like the syntax check in traditional programming environment tools, this checks discovers and indicates both logical errors (like incompleteness or duplications) and simple typos (like identical node names for nodes with different contents).

In fact, the latter will be identified as a "logical error" as well by our procedures. However, at least the author's attention is directed to this assumed logical anomaly and thus, the author may conclude the spelling mistake and provide different names for the different nodes.

All the proposed procedures are implemented in a very general and many purpose tool that we used to compose our storyboards so far: Microsoft Visio (Walker and Eaton, 2003). We are aware that such a tool, which has been designed for other purposes than storyboarding is not the ultimate solution for composing storyboards.

Therefore, we implemented a web based storyboard development environment, which helps an author to compose a storyboard. To include the verification issue as introduced here into this tool is one of next steps.

Furthermore, some validation issues are also subject of our current and future research.

In (Boeck 2007), we introduced a concept to validate paths through a storyboard in advance (i.e. before going the intended path). This concept is based on evaluating paths that have been traversed before (by former students) and applying a particular data mining method to them.

Moreover, besides the evaluation, the estimation can be used for computer enforced suggestions to complete a path towards optimal success chances.

An ultimate objective of validating storyboards is the identification of "successful storyboard patterns". By finding out, what the successful ways through a storyboard have in common and what distinguishes them from the less successful ways, we might be able to discover such patterns.

This research may end up with supplementing our storyboard development environment by a library of successful patterns, which further supports storyboard authors in developing high quality storyboards.

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