52. IWK

Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium

PROCCEDINGS | 10 - 13 September 2007

FACULTY OF
COMPUTER SCIENCE AND AUTOMATION

COMPUTER SCIENCE MEETS AUTOMATION

VOLUME I

Session 1 - Systems Engineering and Intelligent Systems

Session 2 - Advances in Control Theory and Control Engineering

Session 3 - Optimisation and Management of Complex Systems and Networked Systems

Session 4 - Intelligent Vehicles and Mobile Systems

Session 5 - Robotics and Motion Systems

TECHNISCHE UNIVERSITÄT
ILMENAU

Bibliografische Information der Deutschen Bibliothek
Die Deutsche Bibliothek verzeichnet diese Publikation in der deutschen Nationalbiografie; detaillierte bibliografische Daten sind im Internet über **http://dnb.ddb.de** abrufbar.

ISBN 978-3-939473-17-6

Impressum

Herausgeber:	Der Rektor der Technischen Universität Ilmenau Univ.-Prof. Dr. rer. nat. habil. Peter Scharff
Redaktion:	Referat Marketing und Studentische Angelegenheiten Kongressorganisation Andrea Schneider Tel.: +49 3677 69-2520 Fax: +49 3677 69-1743 e-mail: kongressorganisation@tu-ilmenau.de
Redaktionsschluss:	Juli 2007
Verlag:	Technische Universität Ilmenau/Universitätsbibliothek Universitätsverlag Ilmenau Postfach 10 05 65 98684 Ilmenau www.tu-ilmenau.de/universitaetsverlag
Herstellung und Auslieferung:	Verlagshaus Monsenstein und Vannerdat OHG Am Hawerkamp 31 48155 Münster www.mv-verlag.de
Layout Cover:	www.cey-x.de
Bezugsmöglichkeiten:	Universitätsbibliothek der TU Ilmenau Tel.: +49 3677 69-4615 Fax: +49 3677 69-4602

Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.
I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.

Professor Peter Scharff
Rector, TU Ilmenau

Professor Christoph Ament
Head of Organisation

Table of Contents

C O N T E N T S

Paper submitted after copy deadline

2 Advances in Control Theory and Control Engineering

52^{nd} Internationales Wissenschaftliches Kolloquium
Technische Universität Ilmenau
10.-13. September 2007

R. Knauf / S. Tsuruta / Y. Sakurai

Toward Knowledge Engineering with Didactic Knowledge

Abstract

LEARNING systems suffer from a lack of an explicit and adaptable didactic design. A way to overcome such deficiencies is (semi-) formally representing the didactic design. A modeling approach, storyboarding, is outlined here. Storyboarding is setting the stage to apply Knowledge Engineering Technologies to verify, validate the didactics behind a learning process. As a vision, didactics can be refined according to revealed weaknesses and proven excellence. Furthermore, successful didactic patterns can be inductively inferred by analyzing the particular knowledge processing and its alleged contribution to learning success.

1 Introduction

Successful university instructors are often not those with the very best scientific background or outstanding research results. The most successful ones are typically those that successfully utilize didactical experiences as well as "soft skills" in dealing with other actors in the teaching process. Besides the students and colleagues, such actors include e-learning systems as well as the large amount of active (desirable and undesirable, conscious and unconscious) "content presenters" that include news, web sources and advertisements.

The design of learning activities in collegiate instruction is a very interdisciplinary process. Besides deep, topical knowledge in the subject being thought, an instructor needs knowledge and skills in many other subjects. This includes IT-related skills to use today's presentation equipment, didactic skills to effectively present the topical content, plus skills in fields like social sciences, psychology and ergonomics.

In particular, university instruction often suffers from a lack of didactic design. Since universities are also research institutions, their professors are usually hired based on their topical skills. Didactic skills are often underestimated in the recruiting process. We refrain from discussing reasons for that, but focus the issue of involving it a little more. Our approach to facing problems like these is a modeling concept for didactic knowledge called Storyboarding. A storyboard provides a roadmap for a course, including possible detours if certain concepts to be learned need reinforcement. Using modern media technology, a story-board also plays the role of a server that provides the appropriate content material when deemed required. Our suggestion to ensure a wide dissemination of this concept is to use a standard tool to develop and process this model, which is Microsoft Visio.

Section 2 is an introduction to the storyboard concept. In includes the present state of the current development. This is followed by a brief introduction to an exemplary storyboard in section 3. In section 4, we summarize the research undertaken so far and outline current work as well as research horizons.

2 Storyboarding

Former Storyboarding concepts to model information and learning processes have been introduced 1998/1999 [8]. The employment of storyboarding approaches for (unfortunately, only) e-learning is characterized by misunderstandings. So-called storyboard concepts in use are mostly substitutes for software-technological documents of high-level design, but are not very much specific to the instructional design process [3][14]. Didactic concepts [9] are not made explicit and, thus, pondering about didactics is not sufficiently enforced. Again, also very recent approaches as introduced above (see also [13]) remain within the borders of IT systems.

There are contrasting approaches [10] that are conceptually very useful, but syntactically much too far from a workflow directed to technology enhanced learning implementations. The crux is that purely software-technologically driven concepts do not provide an opportunity to represent and discuss details of human learning [2] [4]. Learning is much more than memorizing: "Learning imposes new patterns of organization on the brain, and this phenomenon has been confirmed by electrophysiological recordings of the activity of nerve cells." ([2], p. 121).

Learning is reasonably understood as an interactive knowledge construction process. Illustrative case studies are discussed in [5]. This book's chapter "3B Organizing Shapes" reports process of conversation and co-operation between a teacher and his students in which a variety of media types, forms of interaction, and learners' activities are dovetailed. Didactic design means the anticipation of those communication processes [9], and storyboards may provide the expressive power suitable to the design and implementation of learning processes. This, however, needs to go beyond the limits of software systems specification – the crucial question for innovations in didactic design. Our storyboard concept 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. With respect to a better formal composition, processing, verification, validation and refinement the concept as introduced so far [7] [11] has been further developed. We adopt these modifications. Here, we define a storyboard as follows:

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 subgraph. 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.

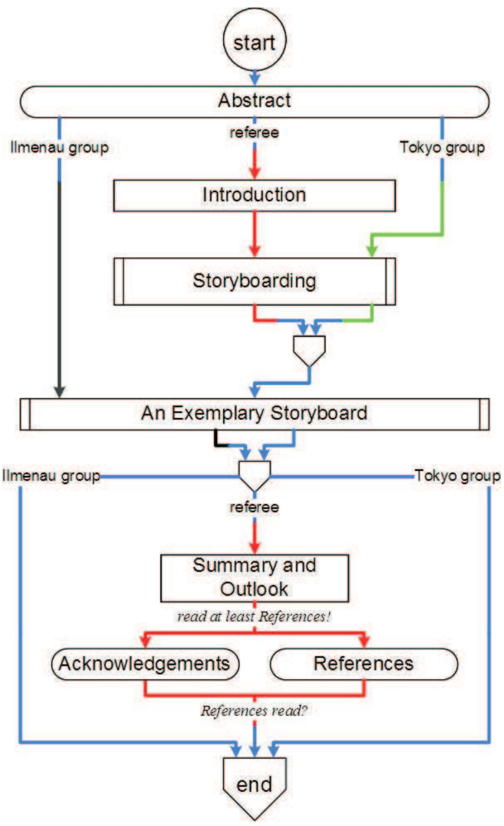


Figure 1: A storyboard on this paper

The interpretations of these terms follow after presenting a small example.

The representation as a graph (instead of a linear sequence) reflects the fact that different readers trace the paper differently according to their particular interests, prerequisites, a current situation (like being under time pressure), and other circumstances. The story-board is the authors' design document representing expectations of human behavior. For exemplification, Figure 1 shows a top level storyboard on the present paper. Alternative paths may be driven by the reader's role:

- The Ilmenau research group may skip sections 1, 2 and 4, because they are familiar with it. Since the example application is new to them, they will study this example.
- The Tokyo research group may skip sections 1 and 4. Since they are interested in the recently developed refinements of the concept, they are interested in section 2. They like to know the way of storyboarding their study and therefore, study the section 3.
- Referees (hopefully) want to read all. After section 4, they can read Acknowledgements and References independently in any sequence. For their duty they have to check the References at least.

A storyboard can be traversed in different manners according to (1) users' interests, objectives, and desires, (2) didactic preferences[1] , (3) the sequence of nodes (and other storyboards) visited before (i.e. according to the educational history), (4) available re-sources (like time, money, equipment to present mate-rial, and so on) and (5) other application driven circumstances. In fact, people may read the present paper in ways that are different from our assumptions modeled in Figure 1. However, for the ways we anticipate, we can ensure that they are coherent. A storyboard may be seen as a model of an anticipated reception process that is interpreted as follows:

- *Scenes* denote a non-decomposable learning activity that can be implemented in any way. It can be the presentation of a (media) document, opening a tool that supports learning (URL or e-learning system) or an informal activity description.
- *Episodes* are defined by their sub-graph.
- *Graphs are* interpreted by the paths, on which they can be *traversed.*
- A *Start Node* of a (sub-) graph defines the starting point of a legal graph traversing.
- An *End Node* of a (sub-) graph defines the final target point of a legal graph traversing.
- *Edges* denote transitions between nodes. There are rules to leave a node by an outgoing edge: (1) The outgoing edge must have the same color as the in-coming edge by which the node was reached. (2) If there is a condition specified as the edge's key at-tribute, 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 traversing on this edge.
- *Free attributes* specify whatever the storyboard author wants the user to know: didactic intentions, useful methods, necessary equipment, ...

Node and edge types, their visual appearance, their behavior on double click, and their behavior when following a hyperlink are as specified in tables 1 and 2 For both forking edges, there is a reverse fork at the end of the forked paths at the point of their merging. This reverse fork is marked with synchronization condition that needs to be satisfied before visiting the subsequent node.

What are peculiarities of the concept? At a first view, this purpose is similar to the purpose of traditional storyboards that are produced for shows, plays, theater games or movies, i.e. visual arts. The materials and tools of the storyboarded learning activities (e.g., text books, scripts, slides, hard- and software models, e-learning systems and others) are something comparable to the requisites of a show. Basic differences of our storyboards to those used to "specify" a show are:

[1]In the authors' experience, some students understand better by presenting illustrations, others by providing a small example and others by providing formal descriptions.

Table 1: Node Types

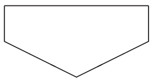
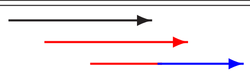
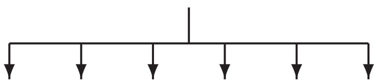
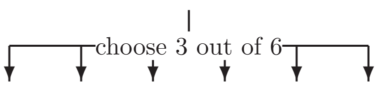
	Symbol	Behavior when	
		following a hyperlink	double clicked
Scene	**Scene**	• opening a document (*.doc, *.pdf, *.wav, *.vsd, *.ppt, *.xls , ...) with the appropriate tool • nothing, if just verbally described scene	• opening a document (*.doc, *.pdf, *.wav, *.vsd, *.ppt, *.xls , ...) with the appropriate tool • visiting a website with the standard browser in case it is an URL • opening the standard mail tool in case it is an e-mail address
Episode	**Episode**	opening a subgraph that specifies the episode	• opening a document (*.doc, *.pdf, *.wav, *.vsd, *.ppt, *.xls , ...) qith the appropriate tool • visiting a website with the standard browser in case it is an URL • opening the standard mail tool in case it is an e-mail address
Start Node	**Start**	jumping to the start node of the related super-graph	not meaningful
End Node	**End**	jumping to the *Reference Node* that successes it's associated *Episode* Node in the related super-graph	not meaningful
Reference Node		jumping to the *End Node* of the subgraph that is associated to the preceded *Episode* Node	not meaningful

Table 2: Edge Types

	Symbol	Interpretation
Simple Edge		defines a unique successor node
Fork		defines several successor nodes, which have to be traversed independently from each other, i.e. in any sequence or parallel
Fork with conditions		defines several successor nodes, which have to be traversed independently from each other, i.e. in any sequence or parallel, according to the specified condition, e.g. take n out of m paths

- the primary purpose (learning vs. entertainment)[2],
- the degree of formalization, and, as a consequence of being semi-formal,
- the obligation of everything above the level of scenes, which does (and should) not apply to storyboards in arts, in which the intendant has some freedom of individual interpretation and
- (thanks to formalization) the opportunity to formally represent, process, evaluate, and refine our storyboards, which does not apply at all to story-boards in visual arts.

Also, Storyboards have somewhat in common with classic AI knowledge representations like *Semantic Networks* and *Frames* as well as with process modeling languages like *State Diagrams* and *Petri Nets* (see e.g. [1] for use in learning processes), *Workflow Diagrams* (see e.g. [12] for use in learning processes) and *Float Charts* (see e.g. [15] for use in learning processes). Items that make this concept more expressive for didactic knowledge than representations as mentioned above are

- the potentially unlimited nesting of graphs,
- the opportunity to express "conditioned" edges by using the colors (bi-colored edges, e.g.) or respective key annotations to edges,
- the opportunity to use (two kinds of) fork-edges,
- the potential of nodes to carry many different teaching materials and tools as hyper-links[3], and, most important, and
- the fact that a scene can be implemented in any way, i.e. is not restricted to something electronically available or even formally structured (like any knowledge representations and any material included in process models).

3 An exemplary storyboard

For *Tokyo Denki University* (TDU), we developed a storyboard on the undergraduate study of *Information Environment*. This project is of a special interest, because TDU introduced some dynamics into the study by a system called Dynamic Learning Needs Reflection System (DLNRS) [6]. For illustration, Figure 2 shows a sub-graph of the episode on *General Cultural Subjects* for the undergraduate study of Information Environment at TDU. To take the individuality and dynamics into account when composing a storyboard, issues like goals, pre-conditions, achieved *Grade Points* of the previous semester and other circumstances need to be formalized and associated to both the related episodes (as a key annotation) and the students. By programming, these annotations to subjects (like their number units, e.g.) and the annotations to students (like the achieved *Grade Points*, e.g.) can be analyzed. This way, storyboards can be individualized and regularly (after each semester) updated according to their new status.

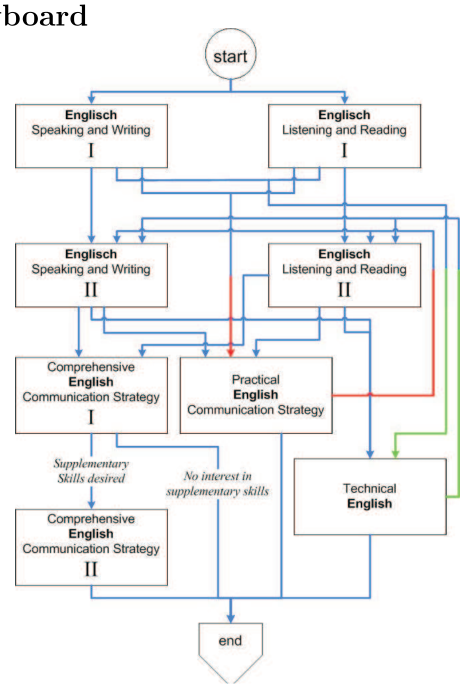


Figure 2: English subjects

[2]This is no ambivalence. To include entertainment into learning is a key of successful learning and an ultimate objective of storyboarding learning processes.

[3]The first author developed a storyboard for an AI course at an US university and included material of his own AI course in Germany. Now, this storyboard serves both universities and is also a common platform for internationally sharing teaching materials.

4 Summary and Outlook

Storyboarding makes didactic design explicit. Since the scenes are not limited to the presentation of electronic material and represent any learning activity, this concept goes far beyond the IT approaches to support learning so far. Representing knowledge at a high level by a modeling concept that is appropriate to be used by topical experts without the need of an IT- or even software technological background is very much AI-driven. To validate the usefulness in practice, we developed several storyboards on various subjects and for a complete university study.

One essential property is simplicity in terms of both the concept itself and the tool we used to implement it. Everybody, also university instructors of subjects that are far removed from information technology, are able to develop storyboards.

Current work is dedicated to following issues: (1) We develop various particular storyboards on many different subjects, that are not limited to university teaching to derive suggestions for the refinement of the concept. (2) We introduce automated storyboard verification by structure tests like (2a) the one-to-one mapping of episode nodes and related sub-graphs, (2b) the tree structure of the graph hierarchy, (2c) the reachability of each node from the start node of its (sub-) graph, (2d) consistency in edge coloring, and (2e) certain condition checks for fork edges and their synchronization when the forked paths merge. (3) We develop a set of basic operations to compose story-boards systematically, which guarantee consistency.

Our *short term objective* of upcoming work is promoting the use of storyboards. As a *medium term objective*, we plan to develop an evaluation concept for storyboards based on the learning results of the students as acquired from the final grade they achieve for the storyboarded courses as well as the students' speific comments in a questionnaire. Our dream and *long term objective* is to identify typical didactic patterns of successful storyboards. Since the learning result of a particular student is associated to a particular path through the storyboard, we will be able to identify successful storyboards in general, but also successful paths within storyboards in particular. By Machine Learning methods, we'll find out what these successful storyboard paths have in common and in which properties they differ from the less successful ones. Thus, we might be able to identify successful didactic patterns. The latter is the vision of knowledge discovery in didactics. By utilizing didactic insights for the upcoming storyboards, we intend to close the loop of the never ending storyboard development spiral.

References

[1] Balaji, V., Arora, A., Jain, A., Goyal, G., Dubey, G., and Singh, S.: SCORM Learning Sequence Modeling with Petri Nets in Cooperative Learning. *Learning Technology*, 7(1), Special Issue on SCORM 2004 Sequencing & Navigation, ISSN 1438-0625, 2005.

[2] Bransford, J.D., Brown, A.L., and Cocking, R.R.: *How People Learn: Brain, Mind, Experience, and School.* National Academic Press, 2000.

[3] Briggs, R.M., Gagne, L.J., and Wager, W.W.: *Principles of Instructional Design.* Thomson Learning, 1992.

[4] Damasio, A.: *The Feeling of What Happens: body and emotion in the making of consciousness.* Hartcourt, 1999.

[5] Davis, B., Sumara, D., and Luce-Kapler, R.: *Learning and Teaching in a Complex World.* Lawrence Erlbaum Associates, 2000.

[6] Dohi, S., Nakamura, Y., Sakurai, Y., Tsuruta, S., and Knauf, R.: Dynamic Learning Need Reflection System for academic education and its applicability to Intelligent Agents. *Proc. of the 6th IEEE International Conference on Advanced Learning Technologies (ICALT 2006)*, Kerkrade, the Netherlands, pp. 459-463, ISBN 0-7695-2632-2,Los Alamitos, CA: IEEE Computer Society, 2006.

[7] Dohi, S., Sakurai, Y., Tsuruta, S., and Knauf, R.: Managing academic education through dynamic storyboarding. (accepted paper) *Proc. of the World Conference on e-Learning in Corporate, Government, Healthcare,and Higher Education 2006 (E-Learn 2006)*, October 2006, Honolulu, Hawaii, USA, 2006.

[8] Feyer, T. and Thalheim, B.: E/R based scenario modelling for rapid prototyping of web information services. P.P.-S. Chen (ed): *Advances in Conceptual Modeling*, vol. 1727 of *Lecture Notes in Computer Science (LNCS)*, pp. 253-263, Berlin: Springer, 1999.

[9] Flechsig, K.-H.: *Kleines Handbuch didaktischer Modelle.* (German) Neuland, 1996.

[10] Forsha, H.I.: *The Complete Guide to Storyboarding and Problem Solving.* ASQ Quality Press, 1994.

[11] Jantke, K.P. and Knauf, R.: Didactic design though storyboarding: Standard concepts for standard tools. *Proc. of the 4th Internat. Symposium on Information and Communication Technologies, Workshop on Dissemination of e-Learning Technologies and Applications*, Cape Town, South Africa, 2005, pp. 20-25, New York: ACM Press, ISBN 0-9544145-6-X, 2005.

[12] Lin, J., Ho, C., Sadiq, W., Orlowska, W.E.: Using Workflow Technology to Manage Flexible e-Learning Services. *Educational Technology and Society*, 5(4), 2002.

[13] Schewe, K.-D. and Thalheim, B.: The Co-Design Approach to WIS Development in E-Business and E-Learning Applications. *Proc. of FIPWIS 2004*, November 24, Brisbane, Australia, 2004.

[14] Rothwell, W.J. and and Kazanas, H.C.: *Mastering the Instructional Design Process: A Systematic Approach.* (Third Edition) Pfeiffer, 2004.

[15] Sykes, E.R. and Franek, F.: A prototype for an intelligent tutoring system for students learning to program in Java. *Proc. of the IASTED International Conference on Computers and Advanced Technology in Education*, Rhodes, Greece, pp. 78-83, 2003.

Author Information:

Priv.-doz. Dr.-Ing. habil. **Rainer Knauf**
Technical University of Ilmenau, Dept. of Computer Science and Automation, Chair of AI
P.O. Box 10 05 65, 98684 Ilmenau, Germany
phone: +49 3677 69 1445, fax: +49 3677 69 1665, E-mail: *rainer.knauf@tu-ilmenau.de*
Prof. Dr.–Eng. **Setsuo Tsuruta**
Tokyo Denki University, School of Information Environment
2-1200 Musai–gakuendai, Inzai, Chiba, 270–1382, Japan
phone: +81 (476) 46 8491, fax: +81 (476) 45 8449, E-mail: *tsuruta@sie.dendai.ac.jp*
Prof. Dr.–Eng. **Yoshitaka Sakurai**
Tokyo Denki University, School of Information Environment
2-1200 Musai–gakuendai, Inzai, Chiba, 270–1382, Japan
phone: +81 (0) 476 46 9081, fax: +81 (476) 45 8449, E-mail: *ysakurai@sie.dendai.ac.jp*