Glossary

Preamble[1]

Several of the terms defined and explained to my knowledge do not enjoy having a commonly agreed understanding neither in the wider communities of "information systems", "artificial intelligence", "informatics", or "computer science" nor in the more narrow community of the contributors of this book. Providing such a glossary on the one hand implies thus quite a risk of getting involved into a fruitless debate of meanings of terms. On the other hand, such a glossary may aid in understanding the chapters in this book. I hope furthermore that this glossary will contribute to the inevitable evolution of term-meanings and will impact higher usability and accuracy. This glossary does not necessarily represent a consensus of all book contributors. I do not believe such a consensus would have been possible. The glossary represents my attempt of providing a unified conceptual base for the *enterprise of aiding the genesis of intelligent assistant systems, as I see these systems now. I have, for a couple of entries, included further references. In a few cases, when I was unaware of a suitable English reference, I provided German references. Terms in italics are meant to refer to glossary entries. The latter are bold face. I thank Gunter Grieser, Klaus P. Jantke, Alexander Krumpholz, and Yuzuru Tanaka for suggestions regarding an earlier version of this glossary.*

Action

"The process or condition of acting or doing (in the widest sense), the exertion of energy or influence; working, agency, operation" (OEDO). In planning the elementary building block of a plan; action may be seen as a syntactic object that has an operational semantics.

Actor

The one acting in a framework in which *actions* occur.

Agent System

See *intelligent assistance*.

Algorithmic Learning

The capability of a *system* of learning to distinguish between the elements of a predefined set of objects by executing an algorithm or program. Executing the algorithm or program enables the system to obtain data that can be used for confirming or refuting automatically generated hypothesis regarding the elements of the predefined object set. Learning is then accomplished if the gathered data is used for working out a set of hypothesis that is sufficient for distinguishing from each other all the objects in the predefined set.

API

Application programming interface. Interface to a software library for developers who want to use that library in their application.

Automatic Assessment

The automated, objective evaluation of task performance. To allow for automatic assessment to take place the quality of the performance has to be measurable.

Cellular Automaton

A *finite state machine* that is capable of communicating with other automata of the same kind and that usually has a rather simple state-space with only a small number of states. John Conway's "game-of-life" is a well-known example of using cellular automata. At http://www.math.com/students/wonders/life/life.html one can find more information and a nice implementation of the game. In this game the automaton's state-space is particularly simple and has only two states, i.e. alive and dead, with the (more or less) obvious state transitions. Assume that a graph is given, i.e., a pair of nodes and edges between them. Two nodes are called adjacent or neighbors if they are connected by an edge. To each node there is allocated an automaton. A subset of these automata can be defined to be in state alive. The state of the game is defined as the subset of the automata that are alive. For each state of the game a follow-up state is defined. For obtaining that follow-up state for each automaton one computes the number of its living neighbors. Then one applies the following rules: (1) a dead automaton with exactly three neighbors that are alive becomes alive itself; (2) an automaton that is alive stays alive if it has exactly two or three neighbors that are alive; and (3) each automaton either dies or stays dead for which the first two rules don't apply.

The graph on which the game is played usually is defined by a chess-board like structure of tiles in which the tiles are considered as the nodes. Two nodes are said to be adjacent if the respective tiles have a common boundary point. It is not difficult to understand this game in terms of finite state machines. Cellular automata can be used for simulating the evolution of large collections of interacting actors with limited individual behavior capacity. Obviously one could play the game on graphs that are inspired by three-dimensional structures such as Rubick's Cube or similar. One could furthermore label the edges of the graph and modify the above rules accordingly such as to break up the symmetry and introduce field effects. For an overview of the history of cellular automata, see e.g., Sankar (2000). A brief history of cellular automata. *ACM Computing Surveys, 32*(1), 80-107.

Choreography

see *coordination*.

Computer

A self-acting device that implements an active *medium* in which a control *process* manages the conditions of *actors* to meet. These conditions include parameters such as the accuracy of representing the utterances they perform, the period of time within which these representations can be accessed, the actors' senses appealed to by the utterances, and the resources the actors have access to. The control process, however, (1) has a representation within the implemented medium that in principle can be accessed and manipulated by the actors and the computer itself, and (2) can be modified by manipulations of that representation. Computers are similar to amplifiers in so far, as they create a process with an imposed structure. They are different from amplifiers in so far as amplifiers take that imposed structure from a dynamic and emerging pattern (i.e., a process) while computers take it from a static pattern (i.e., the control process representation). The currently dominating implementation technology is based on electronics. Patterns of magnetization or voltage are frequently used as the material substrate on top of which the medium is implemented. Mathematical models of the control process include Turing machines, finite automata, the λ-calculus, while-programs, Petri nets and similar. A good source regarding many respective issues is Kozen, D. (1997). *Automata and computability*. New York: Springer Verlag. Computers can be distinguished with respect to whether their basic physical level is conceptualized as discrete (such as binary) or continuous. Computers furthermore can be distinguished with respect to the expressiveness of the language in which the control process representation can be encoded. A computer is usually called general purpose computer if its control process encoding language is as expressive as the language of while-programs. The control-process representation language usually has sub-languages that are tailored towards being highly usable for computer users, i.e., actors who interact with the medium. By incorporating expressions of one of the mentioned sub-languages into the control process representation computer users can modify the control process. The respective activity is called programming (or software development) and the mentioned expressions are called program (or software system). The basic physical level of current general purpose computers is usually conceptualized as discrete. Most recently there are several attempts of employing quantum theory for the conceptualization of the basic physical level of computers, as one believes that significant performance increases can be achieved that way.

Computerized System

A *system* having a component that contains a *computer* or is executed by a computer.

Conditional Judgment

A *judgment* that depends on a logical condition such as judgment U has been made. The concept of conditional judgment enables to in a simple way to deal with aspects of the contextually of human verdictive speech.

Confidence[2]

An *actor's* mental attitude of trusting in or relying on a judgment as well as the degree to which A trusts or relies on the judgment.

Connector

A software component aiding the user of a virtual lab in combining and linking the components of that lab for setting up an experiment.

Constraint

A logical formula or condition, or more general a linguistic expression that is used for restricting the structure, appearance, variability, number, lifetime, etc., of a given class of entities. In data modeling constraints such as multiplicities, cardinalities, functional dependencies etc. are used. In object modeling constraints are put on objects such that their object identity cannot be changed, or that they cannot enter (i.e., become an instance) or leave (i.e., cease being an instance of) certain classes. Languages dedicated to constraint specification have been defined. The currently most well-known of these is perhaps the object constraint language OCL that is a sub-language of the UML. For an accessible outline of the UML and its OCL (that unfortunately is no more up-to-date) see, for example, Bennet S., Skelton J., & Lunn K. (2001). *UML*. New York: McGraw Hill.

Constraint Monitoring

The *activity* of observing and controlling the constraints as applying to an executing process.

Conversational Agent

An e*mbodied interface agent* of a system Σ that is capable of communicating verbally with the users of Σ.

Cooperative Learning

A *process* of acquiring knowledge or skill that involves several *learners* who contribute to the process, each in their way with their individual capabilities, so that their constrained egoisms contribute to a fruitful learning context.

Coordination

"The action of co-ordinating" (OEDO). This in turn means "to place or arrange (things) in proper position relatively to each other and to the system of which they form parts; to bring into proper combined order as parts of a whole." (OEDO)

CORBA

Common object request broker architecture. An architecture standard for distributed system's architecture that is maintained by the OMG.

Course Creator

The human defining the details of a course in a learning institution such as a university or a school. The term in particular is used to refer to the creator of those courses that employ as a key component an e-learning system.

CT

Computer Tomography (or CAT scan), a technique of using x-rays from various angles to generate a three dimensional image of internal structures like the skull.

Declarative Programming

See *logic programming*.

Deduction

A particular mode of reasoning that is based on axioms and rules. See *induction*.

Deontic Logic

A modal logic for reasoning about permissions (*rights*) and *obligations*.

Didactics

The discipline of to how best deliver the content and organize the *learning process* of a particular group of learners such as a class of pupils or students.

E-Learning

Learning processes that may be driven by a particular didactic goal and that are aided by information and communication technology.

E-Learning System

A *computerized system* that is supposed to aid a learner in practicing a form of technology enhanced learning.

Edit Distance

The distance d(A, s, t) which, for an alphabet A and finite strings s and t over this alphabet (i.e., s, t $\in$ A* with A* being the set of all sequences of elements of A) denotes the minimum number of insertion, deletion, or replacement operations needed for transforming s into t. The edit distance is obviously symmetric, i.e., d(A, s, t) = d(A, t, s), for all s, t $\in$ A*.

Embodied Interface Agent

An *agent* that is integrated into the user *interface* of a *system* and the representation of which is guided by the *metaphor* COMPUTER IS A LIVING BEING. This being or character is represented to the computer user as a lifelike "body".

Computer output appears then as utterance of that character which even may be anthropomorphized. Introducing this metaphor to agents has the potential of increasing effectiveness and efficiency of human-computer interaction, as metaphors drawn from the area of communication in everyday life can be exploited. The metaphor in particular involves the various modes of human communication, such as speech, facial expressions, and body gestures.

Executability

The quality of being capable of execution or enactment that applies to a specification. While also structure specifications, such as database schemas, may be executable the predicate is mainly applied to programs or algorithms the execution of which means the instantiation of a *process* inside a *computer* that performs activities as specified by the programs or algorithms.

Execution Time

The time at which an instance of a *process model* is executed.

Explorative Learning

A mode of a learning process in which the learner aims at obtaining an overview of the available content or parts of it rather than at understanding the details.

Federation

The definition and/or execution of selection, interoperation, and coordination of intelligent resources that do not have *interfaces* designed for these tasks.

Feedback

The response of a *system* to an event or trigger in its environment. Feedback is understood as particularly important for human learning in so far as it helps the learner to understand his / her current achievements and deficits. It is one of the big challenges in creating e-learning systems to generate and provide to the learner effective and efficient feedback. The impact of feedback on *learning* performance obviously in part is a consequence of the authority that is accredited by the learner to the feedback provider.

Finite State Machine

F is a tuple F = (S, E, A, C, α, ω, t) where S is a finite set of so-called states with subsets $\alpha, \omega \subseteq S$, the elements of which are called initial and final states respectively. Furthermore, E, A, C are finite sets of events, activities, and conditions. Finally, t is a mapping with the signature t: $E \times S \times C \rightarrow S \times C \times A$. With finite state machines the behavior of a system Σ can be discussed if Σ can be attributed a state and if it responds to external stimuli, the so-called events. Such a discussion is based on the assumptions that (1) Σ initially is in one of the states in α, and that (2) a behavior thread under scrutiny is finished when Σ enters one of the states in ω. The behavior of Σ within a thread of behavior is defined by mapping t which specifies that if Σ is in state s, event e occurs and condition c holds then Σ transitions into state s' and while doing so performs activity a and is in condition c' after that if t(s, e, c) = (s', c', a) holds. The concept of finite state machine can be considered as a *semantic model*, i.e. a model that enables one to create behavior models by providing the basic terms and an overall framework for behavior modeling. In this semantic model the basic terms (i.e., the modeling notions) are "state", "event", "condition", "activity", and "state transition". These modeling notions can be instantiated such as to define individual finite state machines. Creation and representation of finite state machines can be simplified by introduction of abstraction concepts. Abstraction concepts introduce ways of relating to each other domain concepts. Harel has pioneered the use of abstraction concepts with respect to finite state machines. His work was then reused in the object modeling technique OMT of Rumbaugh, et al. A second edition of the book introducing OMT is now available as Blaha, M., & Rumbaugh, J. (2005). *Object-oriented modeling and design with UML*. Upper Saddle River, NJ: Pearson Prentice Hall.

Finite State Transducer

a *finite state machine* that is capable of translating a sub-language S (i.e., a part of a language L) into a sub-language T (of a language M). Often it is assumed that the inputs and outputs of a finite state transducer are represented on an input and an output tape respectively.

Fuzzy Logic

A logic in which the classical assumption is not made that an assertion is either *true* or false. Rather, degrees of truth are considered. Truth values of variables in fuzzy logic may therefore be represented by elements of the unit interval [0, 1]. An assertion in fuzzy logic may therefore be considered as truer than another assertion.

Haptic

The word means related to the sense of touch.

Haptic Device

A computer input/output device which generates three-dimensional force output for the user to feel.

Haptic Workbench

A *computerized system* that has (1) a graphical output device (a monitor), which is visible via a mirror and therefore causes a spatial visual perception in its human user, and (2) one or more *haptic devices* that simulate for the workbench user the capability of carrying out physical operations in the perceived space. The haptic workbench is designed for its users to experience a *haptic virtual environment* in a natural way.

Incomplete Information

True information that is not sufficient for a given *actor* to solve a given *problem*. Take for example a postman in a large city such as New York. If he has to deliver a letter that shows only the name of the receiver and street in which he / she lives but not the house number and apartment number then the information though true might not be sufficient for the letter being delivered and would then considered as incomplete. If one admits problems the solution of which requires infinitely many chunks of information then each finite set of information chunks would have to be considered as incomplete.

Induction

A particular mode of reasoning, i.e., generating a hypothesis H from a presupposition P. In this mode the amount of available *semantic information* is increased, i.e., $\sigma(H) > \sigma(P)$. In contrast to induction the term deduction is used for a reasoning mode in which the amount of available semantic information is not increased. Because of this, deductive reasoning if carried out properly, i.e., if following an axiom system that applies, to a *problem* solving context, does not need to be verified, i.e., it comes to true conclusions if starting from true premises. Inductive reasoning, however, requires verification, as it increases the amount of available semantic information and thus excludes more states or situations.

Inductive Inference

The process of reasoning on information that usually (but not always) is incomplete. The term is in particular used to refer to the process of *learning* from incomplete information such as synthesizing a grammar from expressions belonging to a given formal language, see also *induction*.

Information

See *semantic information*.

Information Extraction

The task of identifying and retrieving structured or semi-structured information (e.g., text chunks) in a document that fit a search condition. In particular in use with respect to processing semi-structured documents that is aided by wrappers. Furthermore, the creation of *information* in response to and for processing documents which are stored in a repository. Information extraction thus not necessarily limited to copying chunks of text found in the documents in the repository.

Information System

A *medium* that was implemented with technical means such as a printing press or a *computer* and that serves the purpose of recording, storing, and disseminating linguistic expressions as well as drawing inferences from such expressions (Langefors).

Intelligent Assistance

A mode of aid in human *problem* solving that is realized by a *computerized system* that has machine intelligence incorporated and that can be distinguished from the mode of aid that is provided by a tool or an agent respectively. Assisted problem solving differs from tool-based problem solving in the following respects. Firstly, a tool leaves the burden of working out a plan for solving the problem to its user. An assistant, however, can be actively involved in finding such a plan. Secondly, an assistant can start aiding its user based on goals of this user while a tool responds only to instructions. Assisted problem solving differs from agent-based problem solving in that an assistant maintains a dialog to its user during creation of a plan for problem solution and while executing the plan. An agent rather only reports details regarding the problem solution (if the problem could be solved).

Intelligentpad

A two-dimensional representation of a *meme-media architecture*. It employs the *metaphor* "sheet of paper" for noting the available *meme media*. Its application to the Web provides a framework for reusing functionality of Web application.

Intelligent Tutoring System

A *computerized system* that uses a set of internal *models* for aiding students in improving their *learning* outcomes by adapting the course to the student. Traditionally this set of models includes a domain model, a student model and a tutoring model.

Intelligent User Interface

An intelligent user *interface* of a *system* Σ, i.e., an interface of Σ that has a reasoning capability incorporated. This reasoning capability often is used for *user adaptation* or for combining basic system services in a way that makes it easier for the user to benefit from using Σ.

Interaction Scenario

Patterns for sequences of exchange acts, as they occur in communication such as human conversation, human-computer interaction, or computer communication.

Interface

The set of operations of a system Σ that is accessible at the boundary of Σ, i.e., the set of components of Σ that directly interact with a system Σ' that does not belong to Σ. Each operation in the interface specifies a kind of stimulus to which Σ responds to as well as the way it responds to in case a particular stimulus of that kind occurs.

Interoperation[3]

A *process* in which several independent *systems* operate in conjunction. This is obviously addressing a form of high-level software-reuse. Making this reuse work is by no means a simple task, as not only functionality of the individual systems needs to be looked at. Rather the used communication protocols, data types, and software architectures and presupposed usage *models* need to be considered, as well as the different versioning policies that are applied to the individual systems.

Judgment

The most elementary kind of verdictive utterance. By means of a judgment an actor A, such as a human, accredits a predicate notion P to the instances s of a subject notion S in a way specified by a copula notion C. A judgment thus can be represented as a predicate U(S, P, C, A). The judgment U(Swan, is white, accredits, John) means thus that John to each instance s of "Swan" accredits the predicate notion "is white". Rather than being a universal notion, as in the example discussed right now, the subject notion in a judgment may be an individual notion, as is the case in the following example. U(US, invades Iraq, accredits, John), which means that John accredits to the United States of America the predicate notion "invades Iraq". The concept of judgment is the primitive unit of verdictive speech, as omitting one of the components of the predicate makes the resulting rest not having the quality of a verdict. For a source on the theory of judgment see Pfänder, A. (1921). *Logic*, (In German). Halle an der Saale: Max Niemeyer Verlag.

Knowledge Acquisition

A process in which an *actor* aims at identifying, accessing, and making operational representations of the knowledge that according to the actor's assumption is helpful for executing a task at hand.

Knowledge Atom

A logically simple description of a fact, i.e., a description of a true assertion that is not composed of other fact descriptions.

Knowledge Base

a set of data items representing facts, i.e., true assertions about some system. Usually one considers a knowledge base as being maintained by a knowledge management system.

Landmark

A point of orientation. Knowing the position of an object relative to a landmark helps to find that object once the landmark is identified.

Learner Model

A particular *user model* that takes into account that the user is a learner; therefore particular aspects are included into the model such as 'achievements in learning', 'time spent with learning objects' and the like.

Learning

A *process* of adaptation of a *system* Σ to its environment such that Σ changes its stimulus-response behavior until further adaptation takes place due to learning or forgetting. One typically would accredit having an internal state and in particular goals to a system that one considers as learning. Learning would then be considered as a process of change such as to more effectively or efficiently achieve the goals. That process of change would be considered as mainly affecting the internal state of Σ. Learning thus can be understood as a process of preparation, of becoming more capable of solving given problems or of acquiring world knowledge. Therefore learning often would be exercised in an artificial environment or context (which is not the problem solution environment or context) such as the ones provided by a learning institution, or a learning session respectively. Application of advanced technology has transformed many of these artificial contexts into virtual ones, as is the case with a flight-simulator (for acquiring or perfecting the piloting skills) or an e-learning system (for acquiring or perfecting theoretical knowledge of some kind). As far as humans are concerned this creation of artificial environments for learning even has a genetic base, as the young individuals for a quite long time and by their nature are not fit for the problem solving environment or context and need care and protection.

Learning Algorithm

An algorithm that creates hypothetical knowledge based on examples or observations, see *algorithmic learning*.

Learning Object

An entity consisting of content and functionality that is maintained by an *e-learning system* and is supposed to be delivered to learners while learning with that system.

Learning Theory

(a) the discipline that theorizes about, investigates empirically and aims at optimizing cases of human *learning*; (b) more specific in the sense of computational learning theory: Mathematical theories of *algorithmic learning*. Its main models are *inductive inference*, PAC learning, and Bayesian inference.

Legacy Application

A *computerized* or software *system* that is operative in the context of a software project such as a development or a maintenance project.

Linguistic Analysis

An analysis of something (such as a text, a situation, a process, etc.) in terms of the language means occurring in that something or that are used to deal with it.

Location-Based Federation

A *federation* of a number of systems that depends on the physical location at which the federation is taking place.

Logic Programming

Programming paradigm the languages of which enable writing programs that are based on (1) declaring facts and (2) providing rules for deriving true assertions from facts and already derived *true* assertions. Paradigmatically the programs written in a logic programming language, such as Prolog, do not contain directions regarding how to in detail obtain the desired true assertions. In so far logic programming differs from imperative programming. Programming languages complying with the latter paradigm are for example C, C++, C# or Java. In these languages programs need to explicitly specify the algorithms for obtaining the values of program variables. Programming languages that do not explicitly specify the algorithms for obtaining variable values are also called declarative. The query languages (such as SQL) that come with modern database management systems are typically declarative or at least have expressive declarative sub-languages. While declarative programming languages often are considered as easier to learn and use than imperative languages the latter often are more expressive than the former ones.

Lookup Service

A service that provides the *information* in a repository that best matches a search expression.

Machine Intelligence

The capability of a machine such as a *computer* to solve *problems* the archetypical solution of which, as executed by humans, involves human experts exercising their cognitive capacities. These capacities are often understood as being a consequence of (1) proper use of stored data that is adequate for the problem to solve; (2) sophisticated ways of deriving hypothesis from facts and already derived hypothesis; and (3) the experience based capability of accepting generated hypothesis for later use or of ruling hypothesis out from further use. Machine intelligence often is realized by programs the execution of which creates processes that are similar or resemble real or potential human reasoning processes. Such programs often are implemented with neural networks or logical programming languages such as Prolog.

Medium

"A person or thing which acts as an intermediary", i.e., as "one who acts between others; an intermediate agent; a go-between middleman, mediator." Also "something acting between persons or things …" (OEDO).

Meme Media

Are *media* for representing and disseminating knowledge that provide direct manipulation operations to humans for editing and disseminating the represented knowledge. A medium is a means enabling agents to meet each other in a way typical to the medium. For example, a book is a medium in which readers can meet authors in the sense that they can perceive their written utterances. The Internet is a medium, as it enables humans to exchange e-mails or to phone each other, etc.

Meme Media Architecture

A software architecture that enables the implementation of *meme media* objects.

Meme Pool

A publishing reservoir of *meme media* objects.

Metadata

Data that is related to other data in the sense that it specifies some of the other data's characteristics or conditions of its use etc. Many different characteristics of data may be important for the users of that data. Therefore many different sets of meta data may be defined and used for each set of data. A frequently used kind of meta data focuses on the structure of that data.

Metaphor

A partial mapping from a cognitive source domain into a cognitive target domain. The mapped concepts in the source domain thus are put into a new context in the target domain. Knowledge regarding the target domain thus can be reused with respect to the mapped source domain concepts. According to Lakoff & Johnson human thinking is essentially metaphorical. Well-known metaphors that were discussed by Lakoff are LIFE IS A JOURNEY and LOVE IS A JOURNEY. In these terms in small caps the term prefixing the infix "is a" is the source domain and the term postfixing that infix the target domain. For more information regarding metaphor see for example Lakoff's chapter in Ortony A. (Ed.). (1993). *Metaphor and thought*. Cambridge University Press (2002 digital printing of the 2nd ed. of 1993). Furthermore the book Lakoff, G., Johnson, M. (1980). *Metaphors we live by*. Chicago: The University of Chicago Press. A number of computer related metaphors was briefly discussed in the preface of this book.

Model

An entity that is used by an actor as a substitute or proxy for another entity (following Stachowiak, see below). The modeler, i.e., *actor* A refers with a model M to a model original O. This reference can be made in a number of different ways, which are denoted as reference modes. Typically this reference is such that (1) A denies some of the characteristics to M that it accredits to O (truncation property); and (2) A recommends using M as a proxy for O only to specified model users, period of time, purposes, location and context of investigation as well as methods and means of such investigation (pragmatic property). Since modeling is not limited to abstracting the model-original reference typically is furthermore such that (3) A accredits to M characteristics he / she does not accredit to O (extension propery). Frequently used reference modes are for example 'descriptive' (A describes O as M, as is the case with the analysis model), 'prescriptive' (A prescribes O as M, as is the case with the design model), 'idealizing' (A idealizes O as M, as is the case with the software process model), and 'constitutive' (A constitutes O as M, as is the case with an ontology for a domain). Models are similar to *metaphors* in that they relate a source entity to a target entity.[4] In Stachowiak's conceptualization models, however, differ significantly from metaphors in that they not only involve a source-to-target mapping but additionally also involve a target-to-source mapping. The first of these mappings is used to translate the *problem* in terms of the original (that one in a modeling case actually wants to solve) into a problem in terms of the model. Provided the model is chosen suitably then one more likely can solve this proxy problem than one could have solved the original problem. The target-to-source mapping is then used to translate the solution of the proxy problem into a solution candidate of the original problem. The modeler is considered as successful if this candidate solution is an admissible solution of the original problem. For more in depth information regarding models and modeling see, for example:

Stachowiak, H. (1973). *General model theory* (In German). Vienna, New York: Springer Verlag.

Lloyd, E. (1998) Models. In E. Craig (Ed.), *Routledge encyclopedia of philosophy* (pp. 443–447). London; New York: Routledge.

The terminology used in parts of artificial intelligence for talking about models and modeling is quite different and more targeted at modeling processes conducted by *computerized systems*. It technically is quite advanced. Respective references are:

Holte, R. C., & Choueiry, B. C. (n.d.). Abstraction and reformulation in artificial intelligence. *Philosophical transactions of The Royal Society: Biological Sciences*, *358*(1435), 1197–1204.

Zucker, J.-D. (n.d.). A grounded theory of abstraction in artificial intelligence. *Philosophical transactions of The Royal Society: Biological Sciences*, *358*(1435), 1293–1309.

Monotonicity

A quality of reasoning *processes* of a particular kind, i.e., the knowledge obtained throughout the reasoning process will not be invalidated by the very process and thus the amount of knowledge as obtained during the reasoning process is not decreasing.

Multimodal Presentation Markup Language

A markup language for defining multimodal presentations.

Natural Language Processing

An automated *process* that has an input parameter, which is a chunk of text in natural language and the syntactical or semantic characteristics of which control the execution of the process.

Navigation

A *metaphorical* denotation of a particular activity in human-computer interaction. The metaphor COMPUTER USE IS NAVIGATION presupposes another metaphor, the metaphor of COMPUTER IS AN INFORMATION SPACE or COMPUTER IS A KNOWLEDGE SPACE. The metaphor COMPUTER USE IS NAVIGATION is supposed to exploit human knowledge regarding the ways of effectively and efficiently move from ones current location (i.e., the source location) in a given part of the world to a target location in that part of world. The set of parts of the real world with respect to which navigation is/was of particular importance includes “ocean”, “space”, “city”, “complex of buildings”, etc. Navigation within these parts of the world usually works such that with a set of dedicated tools firstly the source location is identified, as the relative position of the current location to a point of reference is identified. Secondly, the target location is determined. This involves the purpose of the journey or trip that is made through the affected part of the world. Thirdly, a path is determined that leads from the source location to the target location. Fourthly, that path is actually traversed. Obviously, a number of navigations from a source to a target may be combined. For choosing the path from source to target location as well as for traversing that path a number of models of the part of the world (i.e., maps) is used. To make computer use resemble more navigation first of all a user location in the virtual knowledge space is defined. The user is permanently notified of his / her current location. Furthermore, locations in the information space are named and signs are introduced that (similar to traffic signs) point towards these locations. Additionally there is help functionality available for identifying and explaining the information and functionality that is accessible at the named locations in information space. Last but not least there is transfer functionality (so-called links) accessible for changing the current user location into certain target locations. If for a given target location such transfer functionality is not available then usually an immediate transfer to that target location is still possible if the user knows the name of the target location. For the wider audience the navigation metaphor became a topic only after the invention of the Web. It is, however, worth noting that it is actually in use for quite some time. For legacy computerized systems with complex interface navigation can be used for explaining how to use these legacy systems. A change, however, is that now navigation mainly refers to the content while it in the past referred to the user interface. In more abstract terms can navigation be understood as a process of successive creation of filters for the elements of a predefined set of items out of the meta data regarding these items.

Neural Network

" … is first and foremost a graph, with patterns represented in terms of numerical values attached to the nodes of the graph and transformations between patterns achieved via simple message-passing algorithms. Many neural network architectures, however, are also statistical processes, characterized by making particular probabilistic assumptions about data. … Neural networks have found a wide range of applications, the majority of which are associated with problems in pattern recognition and control theory. In this context neural networks can best be viewed as a class of algorithms for statistical modeling and prediction. Based on a source of training data, the aim is to produce a statistical model of the process from which the data are generated, so as to allow the best prediction to be made for new data." Jordan, M. I., & Bishop C. M. (2004). Neural networks. In A. B. Tucker (Ed.), *Computer science handbook.* Chapman & Hall / CRC and ACM.

Notion

A set of terms that within a given context can be used interchangeably (adapted from Kamlah & Lorenzen, see below). Each of these terms can be used to represent the notion. A term is a word or phrase that for use in a specified context has been given a meaning. While, certainly, for terms and notions a mental correlate exists the definition here avoids using that correlate in an attempt to focus on what makes a notion capable of being intellectual property of a community of humans. For more detail on notions, one may refer to Kamlah, W., & Lorenzen, P. (1996). *Logical propaedeutics: Preschool of sensible discourse* (In German). Stuttgart, et al.: Metzler.

Obligation

A legally, contractually, morally, or otherwise motivated duty to comply with regulations such as to perform or desist certain activities under stated conditions.

Orchestration,

See *coordination*.

Persistence

The quality of enduring temporally. The predicate is, for example, applied to variables that survive the termination of certain programs. That survival may be guaranteed by storing the value of the variable in a database. That database may or may not be maintained by a database management system. For example, the environment variables of an application system such as the standard printer, the location of recently processed files, or user profiles are typically not maintained by a database management system.

Pervasive Computing

An open system of intelligent resources in which users can dynamically select, interoperate, and coordinate some of these intelligent resources to perform their jobs satisfying their dynamically changing demands.

Phantom

A *haptic device* from Sensable Technologies.

Plan

A *model* in the prescriptive or idealizing mode of reference to the *process* of solving a problem. Models of the structure of a building, etc. often are called plan as well.

Plan Execution

The activity of firstly creating and secondly enacting an instance of a plan.

Plan Monitoring

The activity of observing and controlling the enactment of an instance of a plan.

Plan Revision

The subprocess in planning in which a plan has to be corrected according to recently acquired information from other subprocesses such as monitoring.

Planning

The activity of creating a plan.

Planning Assistant

An assistant dedicated for humans to use for working out plans.

Planning Time

The time at which a plan is produced.

Planning Tool

A tool dedicated for humans to use for working out plans.

Presentation Agent

An *embodied interface agent* for delivering presentations that are attractive for humans.

Presentation Style

A term for addressing the particular way in which an e-learning system presents its content to the learner. Usually the learner can choose the style. Examples of presentation styles are example-oriented (a style in which the contents is presented in an example-oriented manner) and theory-oriented (a style in which the contents presentation is oriented at the Mathematical triad of definition, theorem, and proof).

Probability

The likelihood of an event in terms of a formal Mathematical approach. Nowadays the most frequently used Mathematical approach to probability is the axiomatic system of Kolmogorov.

Problem

A negatively assessed difference between a current and a potential state of a *system*.

Process

A coherent real or mental entity that endures temporally and achieves something. Often processes are understood as emergent entities to which several actors or entities contribute their capability to carry out actions. Accordingly processes are defined as partially ordered sets of actions. Due to being emergent processes have characteristics that are not inherited of any of the contributing actors or entities. The set of kinds of process that have been found interesting for computer science includes "business process", "workflow", "software process", "usage", and in particular "learning process". For managing and enacting process specifications a specific kind of infrastructure software system has been invented, i.e., workflow management (and similar) *systems*. The specifications that are maintained by a workflow management system often are called process as well. In that case the actual processes that comply with a given process specification are often called process instance. That is actually a view of the notion process that is consistent with the view of process concept in operating systems or computer architecture. Formal models of process were invented for in particular discussing software specification and program properties. Among the more well-known of these formal models are Petri nets, CSP (communicating sequential processes), CCS (calculus of communicating systems), and ACP (algebra of communicating processes). For much more information on formal approaches to processes and in particular CCS see, for example, Milner's chapter in Van Leeuwen, J. (1990). *Handbook of theoretical computer science, Vol. B: Formal models and semantics*. Amsterdam, et al.: Elsevier & The MIT Press.

Prolog

See *logic programming*.

Proxy Object

An entity that functions as a substitute of a given entity.

Repository Service

A service that enables managing a defined type of structured entities in a database that is called repository.

Right

A legally, contractually, morally, or otherwise motivated permission to comply with regulations such as to perform or desist certain activities under stated conditions.

Ripple Down Rule

An if-then-else-exception rule, i.e. a predicate R(C, X, T, F, E) that includes logical condition C and X, and predicates T, F, and E. The semantics of the predicate is that if (1) $C \wedge \neg X$ is true then T is evaluated, (2) if $\neg C \wedge \neg X$ is true then F is evaluated, and (3) if X is true then E is evaluated. If one interprets X as an exception condition then exception handling is performed in case that X is true. Otherwise T and F are performed in case condition C is true or false respectively. As T, F, and E are predicates they may be ripple down rules and thus ripple down rules may be nested. Nesting these rules, however, should be constrained such that the graph is a tree that results from representing rules as nodes and representing the nesting relationship as directed edges. A set of nested ripple down rules can be understood as representing knowledge if one considers that the predicates T, F, and E may also represent an activity to be carried out by some actor. Nesting ripple down rules thus can be seen as a specific way of specifying preconditions of activities.

Role

The potential behavior of a user of a computerized system. Specifying *obligations* and *rights* of a user is a way of specifying the role of that user.

Search Engine

A *computerized system* that can be used for defining filters and for identifying and retrieving documents stored in a respective infrastructure system (such as the Web, a computer or a document repository) that match the defined filter.

Self-Controlled Learning

A mode of a learning process in which the learner defines the learning outcomes himself / herself.

Semantic Analysis

An analysis of something (such as a text, a situation, or a process, etc.) in terms of what the entities mean that are part of or related to the analyzed something.

Semantic Information

The quality of a constraint to function as a filter and to eliminate states of affairs out of a set of eligible such states. Compare, for example p. 435 of Johnson-Laird P. N. (1988). A taxonomy of thinking. In R. J. Sternberg & E. E. Smith (Eds.), *The psychology of human thought* (pp. 429–457). Cambridge, et al.: Cambridge University Press. The amount σ(C) of semantic information contained in a constraint C is proportional to the cardinality of the set of states of affairs eliminated by that constraint. Filters in application system are a good example of how semantic information works. Take for example the Apple "song" management system "iTunes". It provides the capability of defining a filter (i.e., a constraint) by typing a search string into a window. iTunes filters then those mp3-files out of a play list that match the search string. The more semantic information this string contains, the smaller the number of files that is displayed to the user. If the user wants to listen to a particular "song" then the amount of information contained in the search string S needs to be increased such that out of the play list only a few songs are displayed and a choice can be made out of these based on the meta information available for theses "songs". Note, that the amount σ(S) of information contained in the string S depends on the play list L with which the search string is matched. If too much semantic information is contained in the search string (i.e., this information is inconsistent with the play list) then no "song" at all is displayed to the user. If no information at all or incomplete information is contained in the search string then too many "songs" are displayed to the user for him or her to choose the wanted one. Please note finally that there are many publications about "information". In a recent one Claude Shannon, the inventor of the mathematical theory of communication (that often is referred to as information theory), is quoted "The word 'information' has been given different meanings by various writers in the general field of information theory. It is likely that at least a number of these will prove sufficiently useful in certain applications to deserve further study and permanent recognition. It is hardly to be expected that a single concept of information would satisfactorily account for the numerous possible applications of this general field." Compare, Floridi, L. (Ed.). (2004). Information.

The Blackwell Guide to the philosophy of computing and information (pp. 40–61). Blackwell Publishing. An interesting recent publication is also Lyre H. (2002). *Information theory* (In German). München: Wilhelm Fink Verlag GmbH & Co. KG.

Semantic Model

A *model* that is used in the constitutive reference mode and the original of which is a class of models. It is also known as "modeling grammar" (Ron Weber). It defines what a model (of a particular kind) is and in that sense is supposed to aid in the creation of models. A semantic model provides a number of modeling notions and a number of abstraction concepts. The modeling notions are going to be instantiated by modelers when these cognitively constitute the domain they want to model. Well-known modeling notions are "entity type" (entity relationship-model), "class" (object models), "table" (relational model), or "state" (finite state machines) and similar. The modeling notions of a semantic model function as an ontology, as they enable a modeler to cognitively constitute a domain of interest (also known as universe of discourse). The domain concepts, i.e., the instantiated modeling notions may or may not be type-like. In a finite state machine each of its states typically would be understood as an individual notion. In a class diagram, however, the classes typically would be considered as universals. A class "employee" for example would typically serve as a framework for managing several "employee"—objects, i.e., instances of that class. The abstraction concepts of a semantic model serve as a framework for conveniently relating to each other the domain concepts. The perhaps most frequently used abstraction concepts often are referred to by the terms "specialization", "aggregation", "classification", "refinement", and "abstraction layering". Specialization is often used for deriving new domain concepts by adding detail to already defined domain concepts. Its inverse "generalization" accordingly is often used for deriving new domain concepts by omitting detail from already defined domain concepts. Aggregation is often used for creating new domain concepts out of already defined ones in the sense of a "part-whole-relationship". Its inverse decomposition accordingly is used for breaking up a concept into part-concepts. Classification is often used for defining relationships between domain concepts that are similar to the one between a container and the things it can contain. Refinement is often used for replacing a concept by a model and fit that model into the model that contained that concept. The opposite operation is often called clustering. Abstraction layering often is used for grouping model parts according to the conceptual distance to an actor such as a user.

Semantic Retrieval

A mode of retrieving entities of a given kind, such as documents, that involves a filter that focuses on the meaning of contents of the entities that are searched for.

Semantic Web

A future version of the Web in which parts of documents stored in the Web are annotated with predefined labels such as to enable *computerized systems* to adequately process the stored documents. The semantics achieved by these annotations might be considered as quite limited. Labeling document parts, however, establishes a partially mapping out of a syntactic domain (i.e., the stored documents) without meaning into a semantic domain (i.e., the definitions of the terms used as labels) in which things have an agreed meaning. If more or more rigorous semantics would be needed then more terms might be defined and used as labels or the definitions can be formalized respectively. Finally, the semantics introduced by the defined terms can be used as a *semantic model* (i.e., the labels can be considered as modeling notions) and abstraction concepts can be introduced for creating relationships between the domain concepts.

Semi-Structured Document

A document that does not necessarily fit, or for which there does not exist, a predefined schema, that, however, more or less fits a non-trivial obvious pattern of variable and variable value association. Examples of semi-structured documents are HTML files, XML files, and this glossary.

Shallow Parser

A parser that parses linguistic expressions such as natural language sentences "… to a point where a rudimentary level of grammatical structure and meaning can be realized; this is often used in order to identify passages of text which can then be analyzed in further depth to fulfill the particular objective."

Quotation retrieved February 12, 2006, from http://portal.bibliotekivest.no/terminology.htm.

Similarity Measure

A function s that for each two elements a, b of a set S obtains a quantitative expression s(a, b) that measures the degree of similarity of a and b.

Storyboard

A conceptual specification of the *navigation* scenarios available to the users of a *computerized system*. Storyboards thus can be used in representing a learner community's experiences with a particular e-learning system. Storyboards have been formalized as story algebras and in particular as Kleene algebras with test. Formalized as Kleene algebras (see for a discussion of this type of algebra for example, Kozen, D. (1997). *Automata and computability*. New York, et al.: Springer Verlag) with test equational reasoning becomes applicable to storyboards and can be used for adapting the functionality to the users who have access to it. While this adaptation initially is a design-time adaptation it can be combined with data mining methods and machine learning procedures for identifying changes in the behaviour of users and thus in principle can also be used for run-time adaptation, i.e., after system implementation. It is, however, clear that far reaching changes should be carried out only on respective decision of the user.

Surgical Landmark

A part of the anatomy which helps locating other anatomical structures in surgical anatomy.

System

"… a set of interdependent components (…) that create a whole entity. The components are dynamically linked. That is to say, each one affects and is affected by other components." see p. 73 of Ahituv, N., & Neumann, S. (1990). *Principles of information systems for management.* Dubuque, IA: Wm. C. Brown Publishers. The point that makes the system concept important is its extreme generality, which results in a common terminology being provided for talking about such diverse things as software, organizations, individual living beings, and inanimate entities such as atoms, planets, or solar systems.

For a book dedicated to systems theory, see Baecker, D. (Ed.). (2002). *Introduction into systems theory: Niklas Luhmann* (In German). Heidelberg: Carl-Auer-Systeme Verlag. A couple of mathematical papers contributing to system theory are included in Albrecht, R. (Ed.). (1998). *Systems: Theory and practice*. Vienna: Springer-Verlag Wien New York. Systems are usually studied in their interaction with their environment, i.e., with something they interact with and that does not belong to them. Systems are then supposed to show a stimulus-response behavior, i.e., when certain events happen in their environment then they issue a response. This is what makes the system concept suitable for modeling computerized systems, as it may serve as a framework for implementing stimulus-response relationships as input-output relationships. Each of these relationships that is implemented by a system can be considered as an operation. The mentioned response to a stimulus, i.e., the output to an input, is generated by an event-depending interaction of the system's components. This interaction often is conceptualized as an exchange of matter, energy, or information. The exchange of information can be conceptualized as a communication, i.e., a message exchange. Obviously, for applications of the system concept in computer science the information exchange is of particular importance. The system concept is assumed to be of general applicability. Thus the system components can be considered as systems. This enables a divide-and-conquer approach to systems design being used that is known as method of Langefors. It consists in the adaptation of the ancient Greek method of analysis and synthesis as applied to systems, see Kaschek, R., Schewe, K.-D., Wallace, C., & Matthews, C. (2004). Story boarding for Web-based information systems. In D. Taniar & J.W. Rahayu (Eds.), *Web information systems* (pp. 1–33). Hershey, PA: Idea Group Publishing.

System Adaptivity

The capability and enactment thereof of a system Σ to change its interface such that it better fits the needs, capabilities, or disabilities of its users. The adaptivity of Σ thus not only requires a model of each of its user types incorporated into Σ. Rather, also means are required for deciding which change to carry out under what conditions.

Technology Enhanced Learning

A form of learning that is supported by advanced technology such as *computers*, agents, assistants, and the Internet. One of the driving factors of technology enhanced learning is the high speed with which new products or new versions of new products are created. Traditional learning and teaching is often assumed to be incapable of meeting the current demands. Another driver of technology enhanced learning is the demand to exploit expert knowledge and skill more effective and efficient than possible with current technology.

Temporal Bone

The part of the human skull that surrounds the middle ear and the inner ear.

Temporal Bone Surgery

The surgical procedure of dissecting parts of the *Temporal Bone*. This operation is done for a mastoidectomy, i.e., removal of infected part of the mastoid, or to gain access to deeper structures like the inner ear and a necessary step of a cochlear hearing aid implantation.

Temporal Bone Surgery Simulator

A hardware and software supported simulation of *temporal bone surgery* for use in a training scenario.

Therapy Planning

The process of designing a therapy of a patient's disease.

Truth

The quality aspect of asserting speech that makes a sensible person in an adequate context assent to the assertion (Peter Janich). Note that this is a definition inspired by pragmatism. Other definitions exist. For example definitions that are more in line with a traditional understanding of the philosophy of the natural sciences such as Physics or Chemistry and according to which truth could be understood as coincidence with objective reality. These ways of understanding truth, however, are threatened from suffering either of the following difficulty. As far as is known that has changed significantly over time what was held for true and this includes even the natural sciences and mathematics. This seems to suggest that many beliefs that were held in the past, contrary to what was believed at that time, actually were not true. There is only little reason to believe that this ongoing process ever will stop that results in the things being changed that are held for true. While the truth definition inspired from pragmatism seems to admit an easy to deal with truth criteria (just check it empirically) and has no problem with the historic evolution of knowledge it seems that truth criteria for the alternative approach to defining truth are hard to come up with or to use. For a more in-depth-discussion of truth see, for example, Janich, P. (1996). *What is truth?* (In German). Munich: C. H. Beck.

Two-Level Learning Algorithm

A *learning algorithm* that first learns to distinguish between the types of object and then learns to distinguish between the instances of these object types.

User Adaptation

The process (and its outcome) of changing the user interface of a computerized system or the functionality of that system such that the users of that system can be expected to more effectively and efficiently achieve the goals for which they interact with that computerized system.

User Model

A model of a user of a *computerized system* such as an *e-learning system*. Such a model needs to be incorporated in some way into the e-learning system if that system is supposed to behave in a learner-specific way. If moreover maintainability and exchangeability of learner models are an important design goal then the model needs to be explicitly represented in the *system* architecture as a component. Obviously any *computerized system* has a user model incorporated. This model corresponds to a presupposition regarding what system's functionality and quality makes sense. The user model in general, however, needs not to be explicitly represented.

Virtual Assistant

The first version of an assistant system incorporated in the *temporal bone surgery simulator* as a component.

Virtual Environment

A *system* that creates physical stimuli for the user's senses. For the user this creates the illusion of being in an environment which does not physically exist. The more stimuli are being created and the better their synchronization is, the easier it is for the user to feel emerged in that virtual environment.

Virtual Knowledge Space

The *metaphor* of space applied to a set of representations of knowledge. Venues in space correspond to individual representations and streets or paths between spatial venues correspond to relationships between the knowledge chunks that are represented in the respective venues. Decal information corresponds to links. See also *navigation*.

Virtual Lab

A software *system* that enables a *learner* to practice self-controlled learning by providing the capability of setting up and conducting the experiments that appear reasonable to the learner. The term experiment is here understood as "defining a scenario that can be simulated by the software system and that allows obtaining qualitative and quantitative insight into the scenario." The scenario will, as a key component, contain a model of a structure, a process, or similar regarding which the learner needs to acquire knowledge or the capability of dealing with it appropriately.

Virtual Trainer

The name for a future simulator component, implementing all aspects of an *intelligent tutoring system*. Since it should not only assist the student, but replace the need for permanent feedback by a supervising expert, the name *virtual trainer* was chosen.

Voxel

A cubical data point in a 3D dataset (compares to a pixel in a 2D dataset).

VRML

Virtual reality modeling language. A declarative language to describe a hyperlinked 3D scene.

Web Application

A computer program integrated into the Web and potentially using the Web as a source of content or functionality. Access to these is usually via Web browsers. An HTML-based front-end utilizes resources provided by a remote HTTP server.

Web Information System

An *information system* that is integrated into the Web, i.e., that enables Web users accessing it and that may also enable its users to access the Web.

Web Service

"A Web Service is a software component that is described via WSDL and is capable of being accessed via standard network protocols such as but not limited to SOAP over HTTP." Definition accessed February 12, 2006 from http://www.oasis-open.org/committees/wsia/glossary/wsia-draft-glossary-03.htm.

Wicked Problem

A *problem* that is such that attempts to solve the problem lead to the problem being redefined. Related to Lehman's SPE classification of software that is discussed in software evolution and in which S-type programs (specifyable or static), E-type programs (evolving programms that provide functionality for controlling real world processes), and P-type programms (all programms that are not S-type or E-type) are distinguished. Obviously wicked problems correspond to E-type programms. For more information on software evolution see, e.g., Lehman, M. M., & Ramil, J. F. (2002). Software evolution and software evolution processes. *Annals of Software Engineering, 14*, 275–309.

Wrapper

A program dedicated to extracting information out of documents.

Endnotes

[1] In the sequel a number of quotations is used from the Oxford English Dictionary Online. These quotations are identified with the acronym OEDO appearing as an embraced postfix.

[2] This definition is derived from the one in the Oxford English Dictionary Online.

[3] The definition is derived from the OEDO definition of "interoperable".

[4] Both of them are similar to simile and analog, as they are reference concepts and the purpose of referencing is information transfer.