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Interaction Semantics versus Interaction Syntax in Data Visualization and Exploration: Design, Implementation and Utilization of Meme Media

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Abstract

Humans do not interact with digital systems for the pleasure of clicking buttons. Interactions, in particular those that are quite complex, time-consuming, and sometimes tedious aim at problem solving. Wicked problems are particularly tough. They are characterized by the phenomenon that they tend to change when being tackled. One may see the interaction's semantics as the outcome which–in the case of those wicked problems, at least–is initially unforseeable. The treatment of wicked problems motivates a certain paradigmatic shift from conventional tools to intelligent assistant systems. However intelligent the digital assistant system, the syntax of human-system interaction may be formally represented and is comparably simple in structure. How does such a simple interaction syntax lead to the emergence of intelligent solutions? To what extent do very high expectations of functionality and service impose requirements on the syntax behind? Original concepts of meme media lead both to theoretical insights and to some practical solutions to wicked problems. Data analysis, visualization, and exploration is an attractive application domain. Concepts of interactions scenarios, a meme media implementation, and an application case study are presented.

It does not require an investment of Artificial Intelligence to play Tic Tac Toe, it even does not require much natural intelligence. AI is needed when the problems are involved. When playing more complex digital games, one of the most frequent human goals is having fun. When humans play such a game, say a point & click adventure, a racing game, a first person shooter, or a beat 'em up game, they aim at fun, at satisfaction, sometimes at thrill or at surprise. What they do–seen on a level of fine granularity (see (Lenerz 2009) for a discussion of the varying levels of description based on (Jantke 2006))–is hitting keys, clicking buttons, swiping the finger, or anything like this. This is the syntax of interaction. In the state of flow (Csikszentmihalyi 1990), players do not notice *the syntax of interaction*. They experience, instead, *the interaction's semantics*: stories being told, places they visit[1], quests being mastered, fun, satisfaction, and the like.

Flow and immersion take also place when humans deeply engage in work (Csikszentmihalyi 1990). This paper deals with *the interplay of interaction syntax and interaction semantics* in business intelligence systems and solutions.

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From Tools to Intelligent Assistant Systems

This paper's game-based introduction in the left column is motivated by research and development for transforming, so to speak, digital game toys into digital game assistants (Jantke, Schmidt, and Schnappauf 2016). Transformation of tools into assistants is seen as a mega trend in current science and technology in which concepts and methodologies of AI play a key role (see (Kaschek 2007), (Kreuzberger, Lunzer, and Kaschek 2011), and several of the contributions therein).

In (Jantke, Schmidt, and Schnappauf 2016), the crucial system intelligence introduced lies in the computer system's ability to interpret the human player's behavior of game play that is perceived purely syntactically.

When playing a digital game, those users who have the potential to master the game play do not recognize what may be called the syntax of interaction, but enjoy the experience of semantics[1].

Human beings are used to give meaning to symbols, a need to deal with the complexity of the surrounding world, to give meaning to *the senseless infinity of world affairs*, as Max Weber put it (see (Weber 1904), p. 180).

This point of view resulted later in what is nowadays called *symbolic interactionism* (see (Reynolds and Herman-Kinney 2003) and (Keller 2012), in general, (Fields, Copp, and Kleinman 2006), (Stryker and Vryan 2006), and others, in detail, as well as (Mead 1934) and (Blumer 1969), for the roots including the term itself).

For the role of symbolic interactionism in understanding and, more importantly, in anticipating and designing digital game play, readers may consult publications ranging from (Friess 2012) to (Jantke and Hume 2015).

The aim of the present submission is to extend the former research and development from digital games to proper business applications. The crux lies in the step from syntax to semantics. In data analysis, visualization, and exploration, human users perform human-computer interactions that are fully syntactical. The art is to understand their semantics.

[1] Richard Bartle, with Roy Trubshaw, father in spirit of the Multi User Dungeon: "At the persona level of immersion, the virtual world is just another place you might visit, like Sydney or Rome. Your Avatar is simply the clothing you wear when you go there. There is no more vehicle, no separate character, its just you, in the world" (cited after (Wallace 2006)).

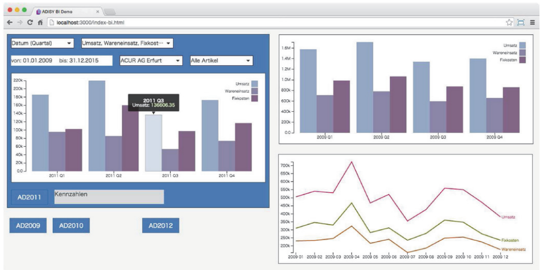

Figure 1: Screenshot from the web-based meme media built application system underlying this conference submission

Perspectives of Human-Assistant Interaction

Throughout the present paper, we will try to be very precise–perhaps, even a bit niggling–when dealing with details of interaction, because the devil is in the details. Therefore, we pay some attention to the underlying terms of *interaction* and *interactivity*. Interested readers should feel encouraged to consult (Hoppe and Lengyel 2010) and, perhaps, some of the references therein.

At a first glance, it seems that both terms are so clear and self-evident that there is no need for a closer inspection. But appearances are deceiving. Opinions like those in (Leggewie and Bieber 2004) and (Struck, Böse, and Spierling 2008) are apparently contradictory.

The crux is that computer scientists are frequently satisfied with the syntax and do not risk to miss the smallest detail. Every keystroke and every mouse click might matter. And sometimes it really does (Schedel and Atzenbeck 2016). In contrast, humanists need meaning as Max Weber put it when defining *action* as "the human behaviour when and to the extent that the agent or agents see it as subjectively meaningful" (see (Weber 1978), p. 7).

Our present paper is intended to bridge the gap. This is not only an issue of conceptualization, because we bridge the gap operationally. We develop, implement, and apply a computational way from interaction syntax to interaction semantics.

Interaction Semantics vs. Interaction Syntax

When humans interact with a digital system, they may have varying intentions in mind. They play games for fun and/or thrill and they inspect data for formerly unknown insights.

(Jantke and Fujima 2016) develops a formal approach that clearly represents varying human-system interactions over time syntactically. In application systems like the one on display in figure 1, human users perform actions such as accessing a database, quering a database, selecting a type of visualization, setting up parameters of rendering, filtering, changing the visualization, modifying the rendering, and the like. All this is syntactically observable. But what is the meaning behind?

Structural properties of observations encode, so to speak, semantics such as goals, intentions, and novel discoveries.

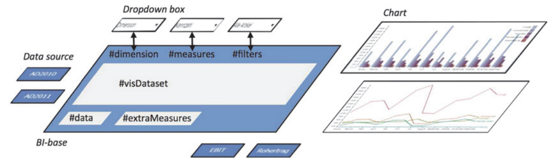

Figure 2: Analysis tool implemented as a compound object

This paper is about concepts for and algorithmic solutions to the computer's understanding of semantics in the syntax.

Meme Media for Intelligent System Assistance

Two decades ago, Yuzuru Tanaka took up the challenge and engaged in the adventure of carrying over philosophical concepts developed by Richard Dawkins (see (Dawkins 1976) for the roots and (Blackmore 1999) for the bearing) toward a novel generation of knowledge media (Tanaka 2003).

According to Tanaka, units of human knowledge may be encapsulated in software modules such that the manipulation of those building blocks bears the potential of knowledge evolution. The software architecture allows for duplication, for mutation, for cross-over, and for natural selection.

Human users may combine those media objects just by drag & drop, may explore the effects of combination, and may change compount objects by peeling off components and plugging them together in a different way

Research Questions & Focus of Investigation

We assume a human being interacting with a digital system that is wielded like a tool.

- *How to transform the tool into an assistant system?*

This is a quite general methodological questions which is investigated in the context of particular application cases where the human's activity is data analysis, visualization, and exploration.

- *How to proceed from tools to assistants for data analysis, visualization, and exploration?*
- *What kind of assistance is particularly helpful when tackling problems of data analysis, visualization, and exploration?*

Assistance is characterized by appropriate response to the human user's actions that, according to Max Weber (see the citation), are meaningful to her. However, the digital system percieves the human's actions only syntactically.

- *How to interpret syntactic manipulations semantically?*
- *In particular, how to do this algorithmically such that the digital assistant can perform the interpretation?*

Further research questions and challenges of design and implementation emerge from the meme media technology in use. According to Tanaka (see preceding section), meme media objects are intended to encapsulate knowledge. Thus, characteristic memetic operations such as connection by drag & drop, peeling off, and direct execution ((Fujima and Jantke 2012), (Jantke 2013), and (Jantke, Arnold, and Bosecker 2016).) may take place, if the system is built upon meme media objects.

- *What is the potential of interpreting memetic operations?*
- *What about the introduction of new media objects that provoke novel interactions bearing the potential to signal significance in human behavior?*

The authors' approach is answering the research questions.

Data Analysis, Visualization, and Exploration: Application Case and Case Study

For shortness, *data analysis, visualization, and exploration* will be subsequently abbreviated by DAVE.

As figure 2 is intended to demonstrate, the authors' DAVE tool is implemented by means of some meme media dialect. Users may interact with the system in a conventional way without any awareness of the underlying memetics. On its way from a tool to an assistant, the digital system may observe the user's behavior. Human activities are manifold such that the system may easily miss the wood for the trees. Therefore, the authors introduced *meme media annotation* (see figure 4 in the right column). Annotations are the key to the problem of significance. Visualization objects with annotations form compound objects that may be stored for a large variety of subsequent processing.

(1) Enhanced DAVE Scenarios

In the authors' present application case study, a subsequence of actions is *significant*, if it ends with a sequence of actions

(i)	mandatory:	*first*, opening an annotation object
(ii)	mandatory:	writing some text
(iii)	optionally:	formatting the object frame
(iv)	optionally:	scaling the annotation object
(v)	mandatory:	connecting to a visualization object
(vi)	mandatory:	*finally*, saving the compound object

where writing, formatting, and scaling may be interchanged and may be repeated several times. Connecting the annotation object to the visualization object may occur at any time between opening and saving.

This defines a pattern that may be represented by some regular expression[2] which is dropped here due to its length.

When studying interaction scenarios, one assumes a finite alphabet A of possible (inter-)actions (Jantke and Fujima 2016). When a user interacts with the DAVE tool enhanced by the option of annotation, some string π from A^* emerges over time. As soon as an instance σ of the introduced *pattern of significance* is discovered, i.e., π has the form $\pi'\sigma$, the pair $\omega = (\pi', \sigma)$ is called a *significant observation*.

Over time, there evolves a sequence of observations $\omega_1, \omega_2, \ldots, \omega_n$ providing key information for adaptation.

In this way, there has been set the stage for transforming the authors' DAVE tool into a DAVE assistant.

[2] Alternatively and equivalently, one may represent it by some non-deterministic finite state machine as on display in figure 3.

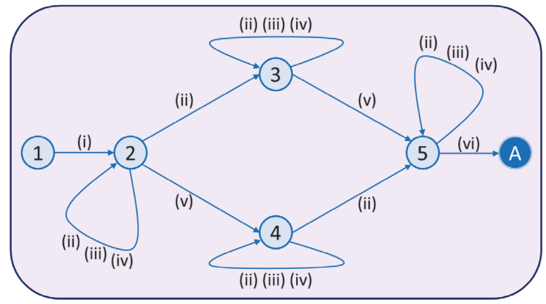

Figure 3: Non-deterministic finite state acceptor for instances of the *pattern of significance* with accepting state A

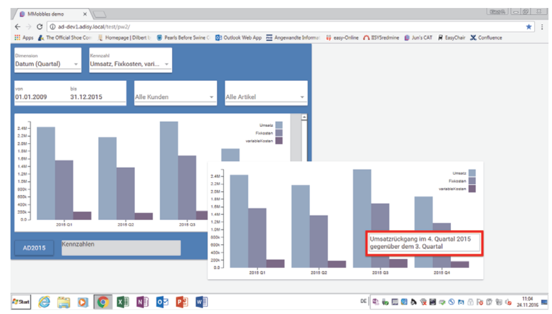

Figure 4: Significance: syntactic evidence of semantics

(2) Learning Semantics from Syntax

The occurrence of an instance of the pattern of significance may be detected automatically (see figure 3). Consequently, a digital system may observe the human's behavior getting fed in observations $\omega_1, \omega_2, \ldots$ purely syntactically. On this basis, the system may attempt *to learn the semantics behind*.

In a sense, the system may *learn what the user has in mind* (Jantke, Schmidt, and Schnappauf 2016).

The data contained in such an instance form the basis for the digital system's intelligence under the hood, so to speak. There are two distinguished levels of observation analysis. First, observations are analyzed individually, and second, different observations ω_i and ω_j are compared to each other.

The observation data on display in figure 4 are taken to exemplify the essentials of the approach.

The annotation (in German) says: "Umsatzeinbruch im 4. Quartal 2015 gegenüber dem 3. Quartal". The key terms[3] of the annotation on display are "Umsatz", "Einbruch", and the temporal terms "4. Quartal", "2015" and "3. Quartal".

The assistant system finds the terms "Umsatz" and all the temporal data in the barchart. Natural language processing transforms the textual annotation into the following formula $2015.Q4.U < 2015.Q3.U$ and logical reasoning leads to $2015.Q4.U < 0.75 * 2015.Q3.U$. This is "understood" as the meaning of the human user's textual utterance.

Understanding the human user is an essential prerequisite

[3] The German word "Umsatzeinbruch" (meaning retracement of business volume) is a compound of "Umsatz" and "Einbruch".

of any *adaptation to the human user*. Let us consider just two examples of the assistant system's potential responses.

- The assistant system finds out and informs the user that $y.Q4.U < 0.75{*}y.Q3.U$ does not hold in any other year y except 2015.
- The assistant system finds the customers c "responsible" for the decline in turnover.

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