BEYOND VISUALIZATION: ON USING SONIFICATION METHODS TO MAKE BUSINESS PROCESSES MORE ACCESSIBLE TO USERS

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1. INTRODUCTION

Making business processes accessible to users constitutes a crucial challenge throughout their entire life cycle: users should be enabled to understand business process models (*Analysis & Design* phase), keep an overview on running process instances (*Operation* phase), perceive process adaptations (*Operation* phase), and comprehend as well as interpret results of analyzing processes (*Evaluation* phase). What sounds easy for small process models quickly becomes an enormous challenge in the context of complex *wallpaper* process models because they can consist of hundreds of process activities, data flows, and resources and can have thousands of running process instances in different execution states. Obviously, for such scenarios it becomes very hard to recognize or even understand, e.g, deviations from the regular process execution path.

Research has been conducted to analyze how visualization methods can help users to understand processes. There exist several tools that offer process visualization approaches to support users to model and monitor business process models and instance data. However, visualization methods for business processes show several limitations [1]: (a) limited screen size, (b) irregular process patterns, (c) executions or large number of process instances in different execution states, (d) displaying process change information as well as assessing certain process analysis and mining results are difficult, yet crucial. In such cases, it can be beneficial to use data sonification in order to enhance process visualizations. Although many reasons appear to apply sonification for representing process-related data, only very few approaches addressed this issue so far. Kramer et al. [2] found out, that the auditory perception is especially sensitive to temporal change. Furthermore, sonification, in contrast to static visualization, can only exist in time. As process instances per definition can only exist in time as well, sonification naturally lends itself to this area (as do animated visualizations). This promises advances when trying to convey process exceptions and changes to users.

2. SONIFICATION OF BUSINESS PROCESSES

One of the few applications of sonification in the area of business processes is the project Grooving Factory [3] of the Jacobs University Bremen. It aimed to reveal bottlenecks in industrial productions and to improve the logistics by sonifying production processes. The developed prototypes enable users to select the different working stations and manufacturing orders of the production process to be sonified.

In the ARKOLA simulation Gaver et al. [4] describe a live multi-modal sonification of a bottling plant. In this simulation, users manually control the settings and adjustments of several interconnected machines, trying to avoid stops and bottlenecks. Occurring events such as the spill of liquid are being communicated to the user by appropriate sounds.

Besides Grooving Factory and the ARKOLA simulation, there seems to be no research project that deals with the sonification of business processes. Research such as that of Hermann et al. [5] deals with the sonification of processes, but not in corporate or business environments (the mentioned example deals with processes in the area of robotics). This leads to the assumption that there still is a substantial amount of untapped research potential in this area.

In order to answer the question which sonification techniques might be best suited to convey business process information, it seems logical to start with analyzing the type and structure of data that typically accumulates during the individual life cycle phases of business processes and subsequently evaluate accepted sonification techniques in terms of their suitability to convey this process information. Most data in the process design phase is related to static process models and their change history. During process operation, the data that typically accumulates can be grouped into two categories: on the one hand, users want to monitor high-level data that accumulates during the execution of the individual process instances (like the number of running instances per process model, current capacity utilizations or the general *health* of the system). This is quantitative data that is updated in regular intervals. On the other hand, users want to inspect individual process instances in more detail in cases of irregularities or specific situations. This instance data is often not very complex and individual data sets typically consist of event occurrences and a few related data elements (like the name of an activity that has been started or completed, together with the name of the associated user and a time stamp), in some cases coupled with quantitative data. However, the data of one such process instance can, in some cases, consist of thousands of such individual events. During the process analysis phase, users want to analyze this execution data in a retroactive, more condensed manner.

The five most accepted sonification techniques are probably *audification*, *auditory icons*, *earcons*, *parameter-mapping* and *model-based sonification*. The techniques audification and model-based sonification may not seem to be the most obvious choices for the sonification of business-process related data. Audification relies on a huge number of quantitative data, which typically is not available to such an extend in this domain. Additionally, it might be very difficult or even impossible to distinguish between several *streams* of sounds using audification techniques. Concerning model-based sonification, Hermann [6] states that audification or

parameter mapping should be preferred to model-based sonification in most cases in which the data that needs be sonified is time indexed. Data that accumulates in the area of business processes is indeed in large part time-indexed.

Auditory icons have already been applied to sonify static models (e.g., [7]), which suggest that they might be applied during the process design phase to sonify process models. During the sonification of the execution of individual process instances (in the phases operation and analysis), the sonic pendants of the involved activities and events could be played back upon their incidences. As an example, a process event "customer has payed his invoice" could be conveyed by playing the sound of a cash register being opened. Analogous, the sound of a shopkeepers bell could signify the acquisition of a new customer. Depending on the industry and the type of processes, there is often a variety of self-explanatory sounds that can be used in order to sonify the respective events and activities. Thus, it would be possible to recognize deviances of individual process instances from more typical process executions by the fact that the respective sounds are being played in a different order, or in a different *rhythm*.

Earcons are in a similar fashion suitable for sonifications during the life cycle phases design, operation and analysis, but more flexible. For some process events it could prove difficult to find real-world-sonic analogies. For example, it could be a challenge to find sounds that are sonic analogies to the states "customer is already registered" and "new customer". This differentiation would therefore be hard to convey using auditory icons, so the usage of earcons might solve that problem (even if studies suggest that earcons are harder to recognize than auditory icons). By using parameterized auditory icons or earcons, not only the information can be conveyed that a certain event has occurred, but also one or several quantitative data attributes that are connected to that event. One could for example imagine an auditory icon conveying the occurrence of an event "incoming payment", while the sum of the payment is mapped to the pitch of that auditory icon.

Parameter mapping might not be suitable for sonifications in the process design phase, as there is little quantitative data to be mapped, but merely static process models. However, during the process operation phase, parameter-mapping sonifications might be used to map high-level data that accumulates during process executions to one or several sound streams. These sound streams might then be played back continuously which should make it feasible for the user to recognize patterns and modifications as well as to get an overview of the general "health" of individual running processes or a complete system. The same (or similar) concepts might be applied to analyze historic process execution data retroactively.

This extended abstract however constitutes just a preliminary analysis of which sonification techniques might be suitable to support users in their business-process related tasks. A more thorough analysis of the specific characteristics of process-related data in the individual life cycle phases will be necessary before making decisions concerning which sonification techniques will be applied during the development of respective prototypes.

Besides the fact, that different sonification techniques might be adequate for different tasks that users perform during the different life cycle phases of business processes, the two modalities visualization and sonification might also be suitable to different extends for these areas. In the process design phase, visualization might be more suitable than sonification. Graphical user interfaces already allow the user-friendly creation of process models, a task that may not benefit substantially from sonification. However, after (or during) the graphical creation of process models, sonification might well be helpful when it comes to simulating process models in order to test them for potential problems (such as deadlocks). During process operation, a sonification could be used to monitor the execution of process instances. One could imagine, depending on the scenario, either a constant real-time sonification of all running process instances, or an *auditory summary* of a certain time period (for example a shortened sonification of the last 24 hours). In such a sonification it should, after a learning phase, be possible to detect deviances or critical situations during the execution of process instances. A multi-modal solution could combine sonification with the possibility to visually explore root causes or other details, once such a situation has been recognized in the sonification. Similar approaches could be applied in the process analysis phase. In general, multi-modal sonifications of business process-related data should consider the strengths and weaknesses of both modalities in order to be able to best assist users in their tasks.

Future work will result in first recommendations on how to apply multi-modal approaches in the context of business processes along their entire life cycle. Subsequently, prototypes that base on those results will be developed and evaluated.

3. REFERENCES

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