

TimeTube

Assist Scientists to Enhance Laboratory Scheduling

Calculation of optimized execution plans in analytical laboratories is a demanding task for computers: It can take a long time and because of activities that have variable durations the calculated execution plan can be fairly imprecise. We present TimeTube, which is a haptic visual user interface that allows scientists to adjust and speed-up scheduling processes manually – and thus to combine the processing power of a computer with the vast application knowledge of a human user.

Analytical laboratories have to analyze multiple analytical assays – represented by workflows – in parallel. Mathematical algorithms are used to distribute the workflow's activities to a pool of instruments – some of them with several instances. Each instrument is capable of performing one or more identical or different tasks at the same time. Schedulers, i.e. programs that implement these algorithms, can optimize towards a maximum workload, minimization of throughput duration per sample, minimum reagent consumption, etc. Workflow editors may even add transport steps automatically so that the chemists need to concentrate on the relevant chemical activities only.

The more workflows a scheduler has to consider in its calculation the longer it will take. The workflow complexity in terms of number of activities, parallel threads, conditioned branches, loops etc. and the variability of activity durations, e.g. incubation influenced by cell division processes, also increase the calculation time. Even worse, the scheduler may allocate instruments for a long time span.

If calculation of a complex schedule takes too long a scientist should be allowed to interrupt the scheduler and complete a schedule manually. Additionally, a scientist can apply expertise to add more restricting constraints or predict exact durations for activities with variable durations – and therefore reducing the allocation of resources in the schedule.

TimeTube allows to speed-up scheduling

The TimeTube allows users to provide additional constraints for the scheduling algorithms. It is specifically designed to assist laboratory staff in interacting with a software scheduler. The collaboration of the TimeTube with the scheduler is displayed in Figure 2:

1. Workflows of all tests to be processed are sent to the scheduler in XML format.
2. The scheduler starts its calculation.
3. The user may interrupt the scheduling process at any time and obtain the current state of the schedule as XML data, which is then automatically visualized by the TimeTube.
4. The user edits the schedule in TimeTube generating new constraints, e.g. new activity durations or instrument allocations.
5. The user sends the edited schedule in XML format back to the scheduler.

6. The scheduler obeys the changes in its calculation process, which may be interrupted again.

Editing schedules of analytical workflows in GUIs is not new. There have been other approaches, which employed 2D visualization techniques like Gantt charts for visualization and interaction purposes [1]. However, Gantt charts exhibit major disadvantages: It is difficult to display and manipulate short and long activities simultaneously. Reordering of activities with drag-and-drop techniques has proven to be not useful as interaction techniques in many cases. Either only a small part of the information is visible at a time when zoomed in or necessary details are not visible when zoomed out.

TimeTube combines findings of interaction and visualization research

In TimeTube recent innovations made in three areas of Human Computer Interface research were applied in order to provide intuitive software (see figure 3). The TimeTube is based on a 3D visualization that adopts positive aspects of Gantt charts while minimizing their negative aspects. The TimeTube employs a new focus and context technique in order to present the whole schedule at a glance in the context view while showing detailed parts of it in the focus views. In figure 4 the context view is displayed on the bottom and the two focus views on the top. These views show one tube that holds the schedule from three different perspectives with different levels of detail.

Inside this tube boxes are dispersed that represent activities. If activities belong to the same workflow they will be connected with a line in order to provide a better overview of workflow cohesion. The same color of a box denotes the same instrument on which they will be carried out. Time is mapped on the z-axis, the central axis of the tube.

Phantom Omni is used for user interaction with TimeTube

At present, mainly 2D input devices like a mouse are used for interaction. However, interaction with a 3D representation of data can be difficult with a 2D mouse. To reduce the complexity of the interaction, the TimeTube is used with a haptic 3D input device called Phantom Omni [2]. In addition to navigation in a plane perpendicular to the z-axis, the pen of the Phantom can be moved along the z-axis denoting movements forward and backward in time. The user controls a pointer (the white ball in figure 4) with the Phantom. The purple ring indicates the pointer's position on the z-axis.

When a user selects a box with the pointer, the box can be moved forward and backward in order to change the execution-starting time of the activity represented by the box. As activities must stay in the correct timely order, the TimeTube may automatically adjust the position of other boxes. A user can also change the execution duration of an activity by resizing a box's size, e.g. to predict the incubation duration of a sample. Whenever the pointer touches an activity, detail information of it will be shown as text in the middle of the tube.

The TimeTube program is capable of exerting forces on the Phantom's arm. Thus, the Phantom can give haptic feedback supporting the user to interact with the visual

3D representation of the schedule. Haptic feedback is used in the following situations within the TimeTube:

- When the pointer touches the virtual boundaries of the tube, forces are exerted on the pen that create the illusion that the virtual walls cannot be penetrated.
- A box in the tube can only be moved along the time axis when selected with the Phantom.
- A force will work against the movement direction of the Phantom's pen if the pointer leaves the working area between the two red rings. In this situation the application starts to scroll in the tube with a certain speed. The scrolling speed will be the faster the harder the Phantom's pen is dragged or pulled.

Figures:

Figure 1: Usage of TimeTube

Figure 2: Collaboration of Scheduler and TimeTube

Figure 3: Combination of findings from different research areas for TimeTube

Figure 4: TimeTube GUI

Sources:

[1] Schäfer, R.: Concepts for Dynamic Scheduling in the Laboratory, JALA 9,6 (2004) 382 – 397

[2] SensAble Technologies, 2008, PHANTOM OMNI – Sensable. Available from: <http://www.sensable.com/haptic-phantom-omni.htm>

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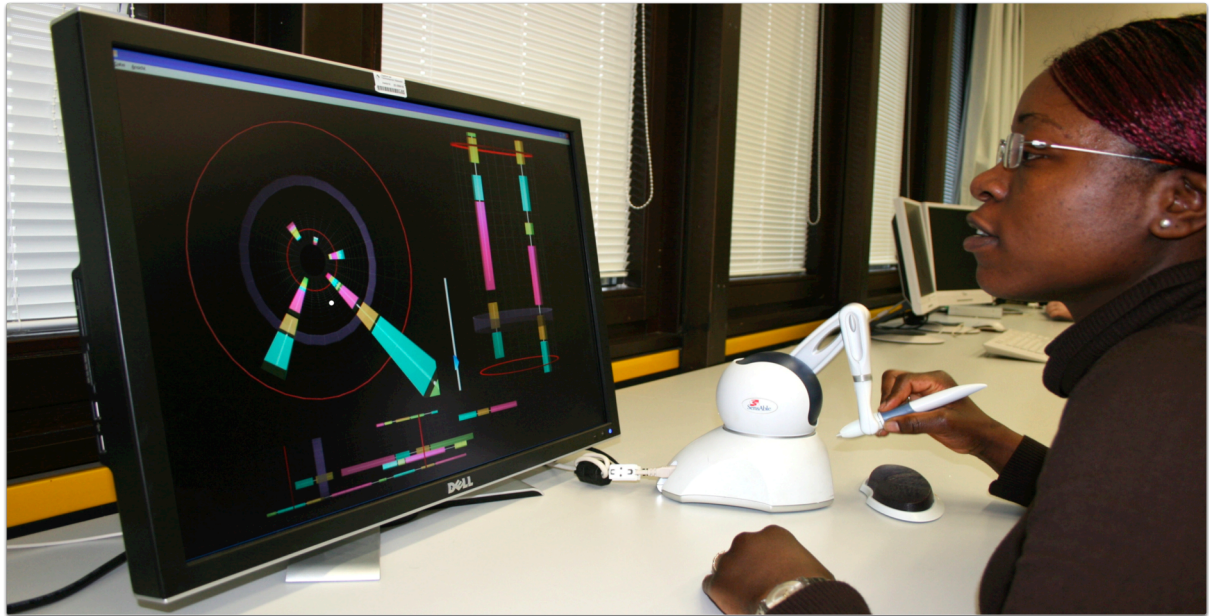


Figure 1: Usage of TimeTube

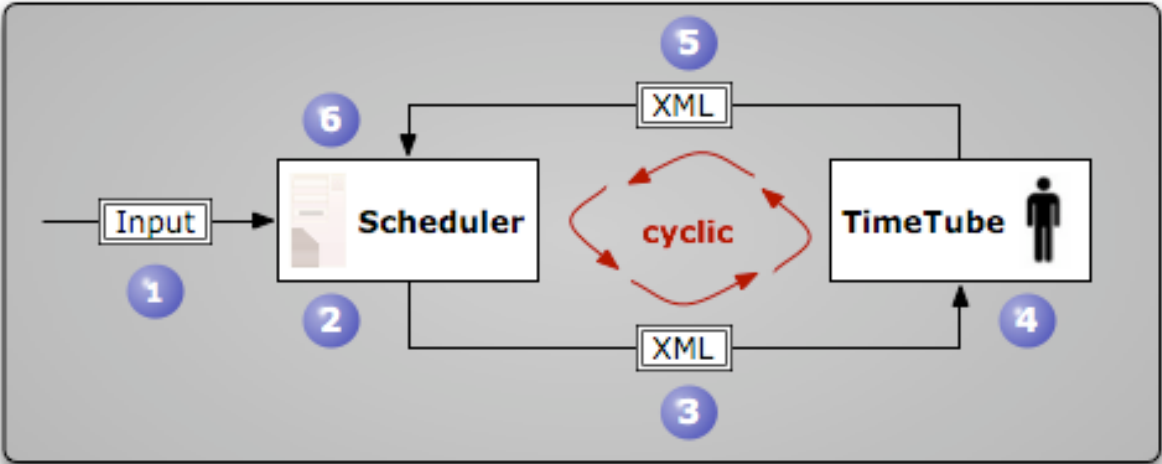


Figure 2: Collaboration of Scheduler and TimeTube

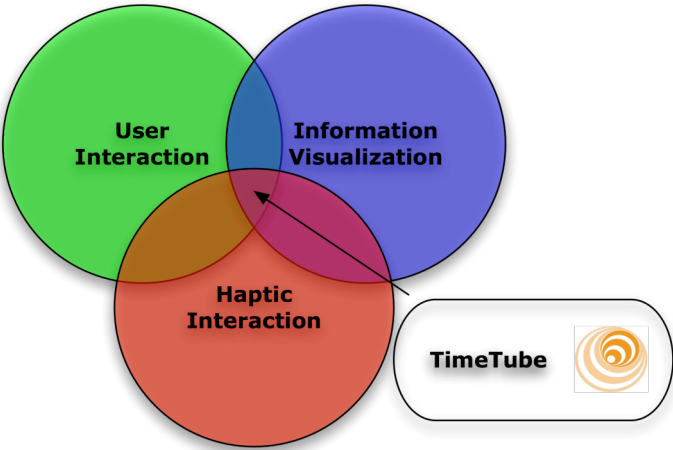


Figure 3: Combination of findings from different research areas for TimeTube



Figure 4: TimeTube GUI



Picture of the author