Exploring Simulation Scenarios with Timepoint Thumbnails

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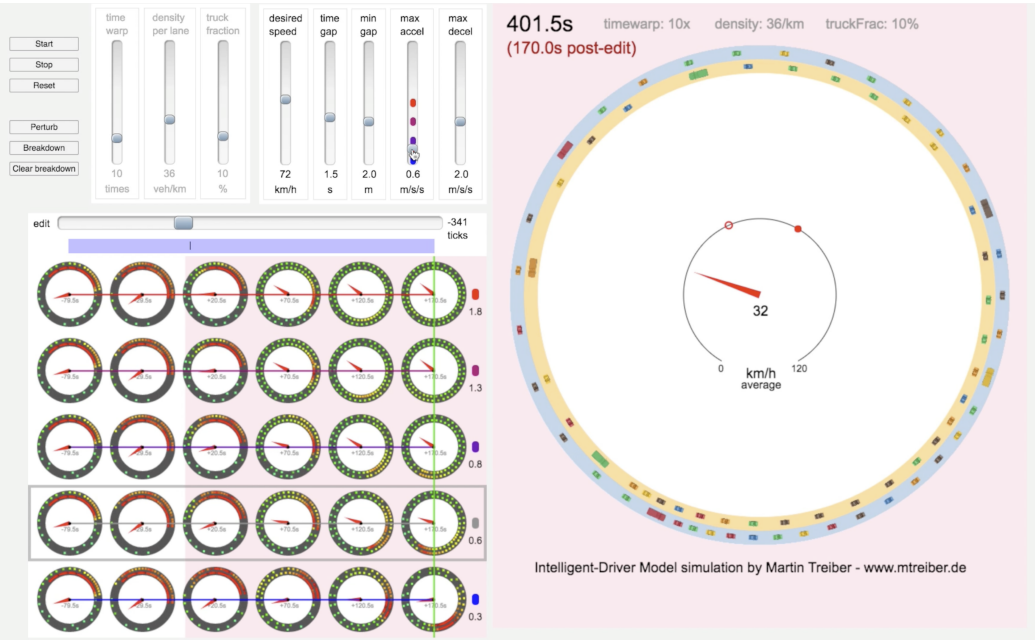

Figure 1: A traffic simulation, wound back in time to explore the impact of model parameters on how quickly a traffic jam will disperse. At lower left, five rows of timepoint thumbnails show how the simulation would proceed with five alternative values for one of the parameters: the lower the value, the more we see slow-moving or stopped (yellow or red) vehicles in the latest thumbnail, at the right-hand end. The full-size view shows this final state for the selected (boxed) row.

Abstract

A dynamic simulation helps its users to explore the behaviour of a modelled domain. Exploration is further enhanced if the users can also see and interact with a history of the simulation results. We present a history interface based on what we call timepoint thumbnails: temporally spaced dynamic views that capture the salient features of a simulation's moment-to-moment state. As an example, we show how this interface can assist in exploring emergent phenomena in simulated vehicle traffic.

Index Terms: I.6.8 [Simulation and Modeling]: Types of Simulation—Animation; H.5.2 [Information Interfaces and Presentation]: User Interfaces—Graphical User Interfaces (GUI)

1 Introduction

A simulation that plays out over time, and is embedded in an interface that lets a user observe on the fly the impact of adjusting simulation conditions, is a rich resource for study. There are further benefits if the interface also supports interaction with a moment-by-moment history of the results—for example, allowing otherwise ephemeral changes to be examined at leisure, and enabling 'what-if' analysis based on re-running a simulation period with the same input events but different parameter settings. In general, however, the visualisation of such rich time-oriented data presents many challenges, especially when extended to multiple simulation runs [1,3].

Here we describe a simple visual approach to history exploration, suited to simulations whose main result view can be scaled down to create live *timepoint thumbnails* that still have sufficient detail to convey the simulated objects' motion. A history is shown using a row of such thumbnails, in which each presents the state of the simulation some fixed time into the past relative to its neighbour.

We demonstrate the use of timepoint thumbnails on a traffic simulation[1], which we control and display in a custom interface built with the Lively Web browser-based environment [2]. Basic features of the interface, seen in Figure 1, are buttons to let a user start and stop the simulation, and sliders to adjust parameters of the Intelligent-Driver Model that determines how vehicles react to traffic conditions. There are also buttons for perturbing the simulation, such as by causing a randomly-selected vehicle to come to a halt as if broken down, then later to be 'repaired' and rejoin the flow.

The thumbnails approach was designed and prototyped by media-interface researcher and sometime colleague Robert Ochshorn. It relates to two of his video projects from 2013: *Chewing*[2] and *livezoom*[3].

For more details, see `https://tinlizzie.org/traffic/`.

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[1] We use a minor adaptation of a ring-road example implemented by Martin Treiber at the Technical University of Dresden, downloaded from `www.mtreiber.de` in early 2015. All vehicles are moving anticlockwise.

[2] `https://rmozone.com/snapshots/2013/05/chewing.h264.mov`

[3] `https://rmozone.com/snapshots/2013/05/livezoom/`

2 History visualisation and interface

The thumbnail renderings that we developed for the traffic simulation show the vehicles as small squares, coloured to represent their instantaneous speed (green when fast-moving, red when stopped). Parts (a) to (c) of Figure 2 show how a history display builds up when the simulation is started. The rightmost thumbnail shows the current state, and each successive thumbnail to the left is 5 seconds into the past (which, with the default simulation speedup factor of 10, represents 50 seconds of simulated time). The interface in Figure 1 has room for six thumbnails in a row—implying a history that spans 250 simulated seconds, which is enough to show typical transient effects in this simulation. Showing more thumbnails, and hence a longer history, is basically just a question of display space.

Each user-initiated event—slider adjustment or button press—is represented as a vertical bar on the purple strip above the thumbnails. These bars move 'into the past' by stepping leftwards with each simulation tick. In Figure 2(c), for example, a bar representing a 'breakdown' event has just passed the centre-point of the third thumbnail from the right; the corresponding stopped vehicle is seen in red near the 10-o'clock position in that thumbnail.

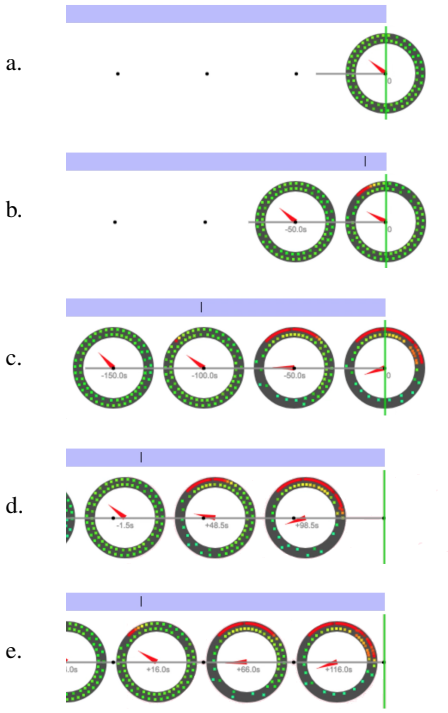

Figure 2: Growth and use of the thumbnail display. **(a)** immediately after starting simulation; **(b)** after 50s of simulated time, a second thumbnail (50s in the past) appears; **(c)** the blockage that was introduced just before (b), and has just reached the 100s thumbnail, has resulted in a traffic tailback; **(d)** user has stopped the simulation and switched to 'marching' mode—the thumbnails are marching to the right, with one thumbnail about to encounter the blockage event; **(e)** a moment later, that thumbnail shows the blockage.

2.1 Browsing recorded history

When the simulation has run for a while and built up a history, the user can pause it and review what has happened.

One way to review is to grab the 'edit' slider, seen above the thumbnails in Figure 1, and move it to the left. As the slider is moved along the timeline, the main display instantly updates to show the simulation state from that point in time.

A second form of review is provided by the thumbnail display's 'marching' mode, which the user can toggle on and off. In this mode, as shown in panels (d) and (e) of Figure 2, the thumbnails themselves move from left to right, replaying what happened at each tick along the way. When a thumbnail reaches the right-hand end of the line it disappears, and a new one appears at the left. This endless replay allows for fixing one's gaze at any point on the timeline and seeing the simulated objects' movements repeat every few seconds; such *timeless motion* [4] helps reveal patterns and rhythms that might otherwise be missed.

2.2 Replay with adjustable starting conditions

In the standard use of this simulation, the cars progress around the circuit under the eyes of the user, who can observe the emergent properties of the traffic flow—for example, the appearance, movement and dissolution of 'phantom traffic jams' in heavy traffic.

The simulation can instead be run through hundreds of ticks almost instantaneously, which we use in supporting explorable replay. For example, suppose a user triggers a breakdown that leads to a tailback, then clears the breakdown and watches to see how the traffic flow resumes. After a while, the user can pause the simulation and rewind the 'edit' slider to a point in time before the breakdown was cleared. Adjusting any of the parameter sliders will now cause all recorded ticks *after* the edit time-point to be re-run, including reapplication of the 'clear breakdown' event. The main display will immediately show the state that the simulation *would have reached* at the point where the user paused it, had the parameter settings been as they are now. The intermediate history, and thus all the thumbnail displays, will also be updated.

2.3 Parallel exploration using multi-setting sliders

Figure 1 additionally shows how this interface supports multi-scenario comparisons. After setting up the situation described above, the user has right-clicked on the 'max accel' slider (which controls how quickly a driver will accelerate when the road ahead is clear) to set up five scenarios with different acceleration values. The fates of the simulation under these different conditions are seen in the five rows of thumbnails. It is clear at a glance that in the lower rows—corresponding to the lower acceleration values—the flow has not recovered well, with regions of stationary traffic (drawn in red) remaining in the right-most thumbnails.

3 Conclusion

The visualisation and interaction techniques introduced here met our goal of encouraging and enhancing exploration with the traffic simulation. We are continuing to experiment with the techniques, such as by incorporating timepoint thumbnails into other (non-simulation) applications with time-based visualisations. We hope that other designers will also find a range of uses for this work.

Acknowledgments

The author gratefully acknowledges the support of all his colleagues in Viewpoints Research Institute and in Y Combinator Research's Human Advancement Research Community. Special thanks go to Robert Ochshorn as inventor of the thumbnail visualisation!

References

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