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Problem

Time-series visualization techniques

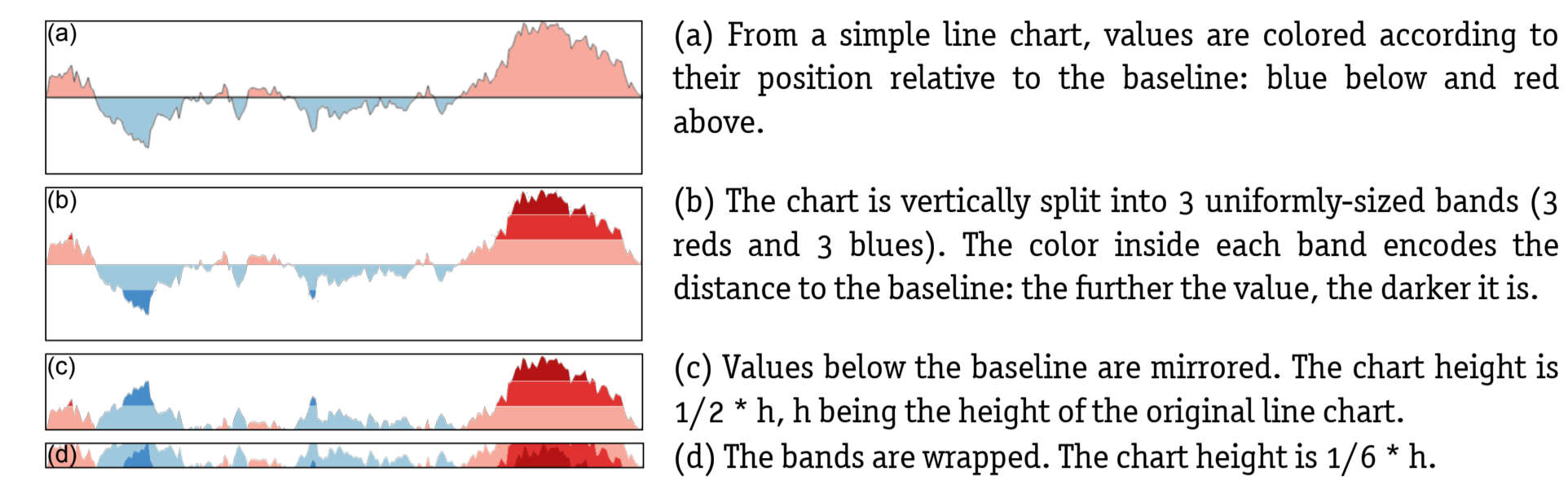
Despite being the simplest way to represent time series, line charts fall short when it comes to visualizing multiple time series because the limited vertical screen resolution can result in high visual clutter.

Split-space techniques (each time series occupies its own reduced space) are more adapted to large numbers of time series than shared-space techniques (where all the time series share the same space).

The two split-space techniques we rely on are:

- **RLC**: Reduced Line Charts: Small Multiples for time series.
- **HG**: Horizon Graphs, developed by S. Few (Panopticon) use 2 parameters: the number of bands and the value of the baseline separating vertically the chart in positive and negative values.

Construction of a HG with 3 bands and a baseline at the half of the y axis



Progressive Horizon Graphs technique

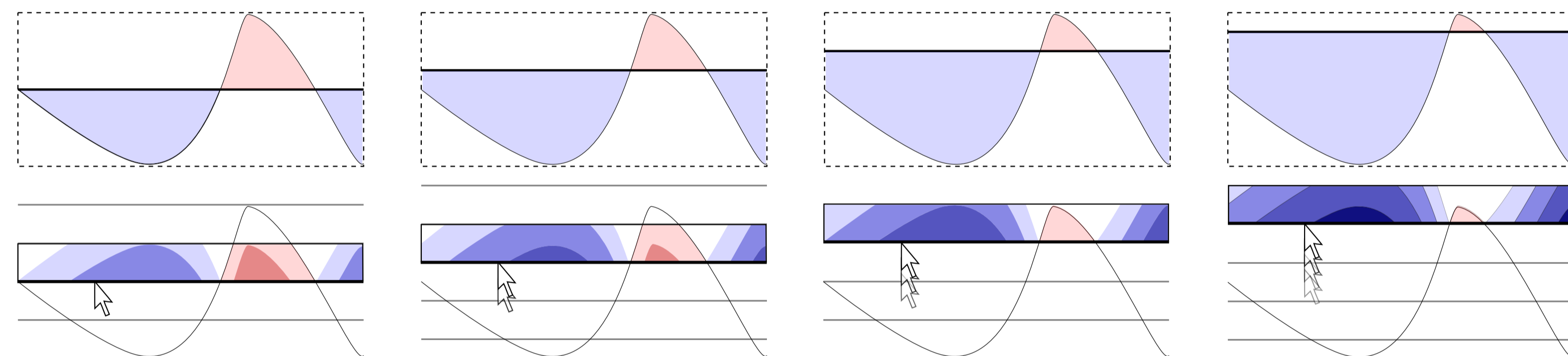
Progressive Horizon Graphs (PHG)

PHG are the unification of RLC and HG by introducing interactive techniques, allowing HG to be effective for larger numbers of time series. The 2 parameters of HG are controlled using a variant of Pan & Zoom along the y axis: the pan sets the value of the baseline y_b separating blue and red values and the zoom factor z is applied to values and controls the number of bands.

Baseline panning

- continuous translation of the baseline along the y axis which does not change the height of the chart.
- All the multiple charts baselines are changed simultaneously by one user interaction. Since the baseline is always at the bottom of the chart, the perceived translation offsets the chart values inside its frame and changes the coloring of the charts.

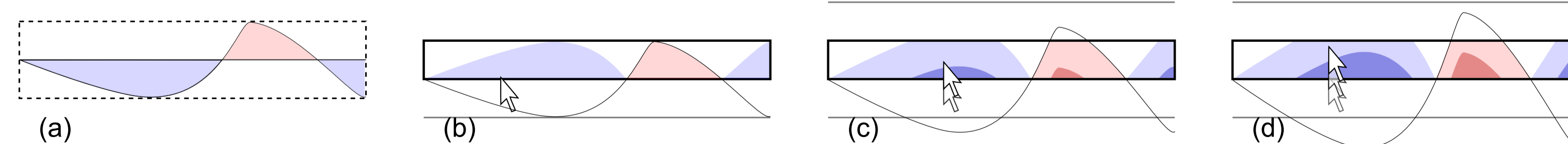
- Overcomes a limitation of the fixed baseline supported by HG: because the pre-attentive color perception is only efficient for values around this baseline, we provide a way to interactively set this baseline.
- Changing the baseline value becomes particularly valuable if one is interested in visualizing the time series around a specific value, baseline panning highlighting the variations around a value of interest.



Value zooming

- Allows users to specify the zoom factor for values using a continuous interaction.
- Does not change the scale of the x axis, unlike regular zooming would, and does not change the height of the chart either: values wrap around the lower border of the chart. The chart can be seen as if drawn on a tallsheet of paper which is wrapped around its baseline according to the zoom factor z : when the shape of the chart reaches the top of the y axis, it is cut and appears at the bottom of the y axis, with a more saturated hue.

- HG use a discrete number of bands, so changing from 2 to 3 bands triggers a sudden transition. Value zooming prevents this abrupt change, resulting in a smooth and continuous zoom.
- The appropriate zoom factor depends on the scale of the variations to analyse: observing small or large variations will result in a high or low value for the zoom, respectively.
- While standard zooming techniques consist of focusing on a specific area and losing the context information, our zooming implementation preserves both the visibility of the context and the details on small variations around the baseline.

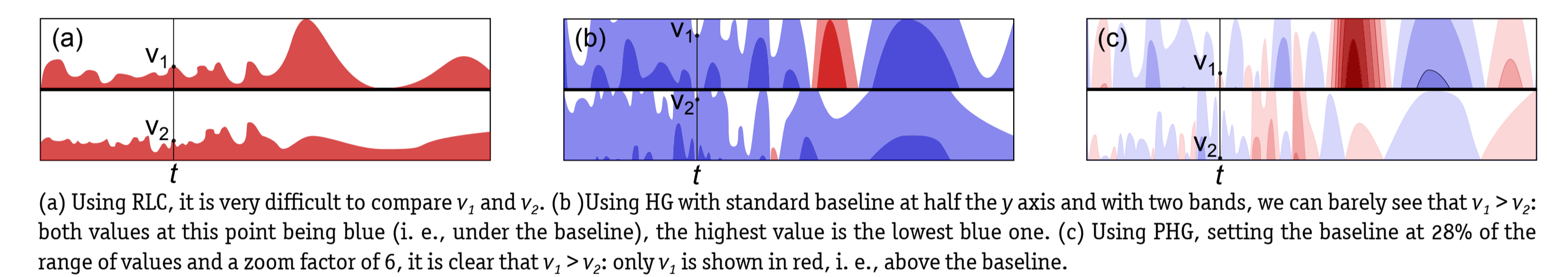


From left to right, (a) Pan sequence, (b) Zoom sequence.

Progressive Horizon Graphs in action

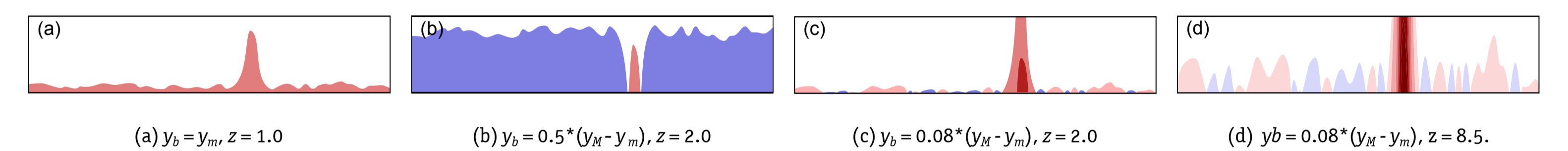
Basic task: find a maximum

The difficulty to determine which one of the two time series has the highest value at point t (marked by a vertical black line) is different for each visualization technique.



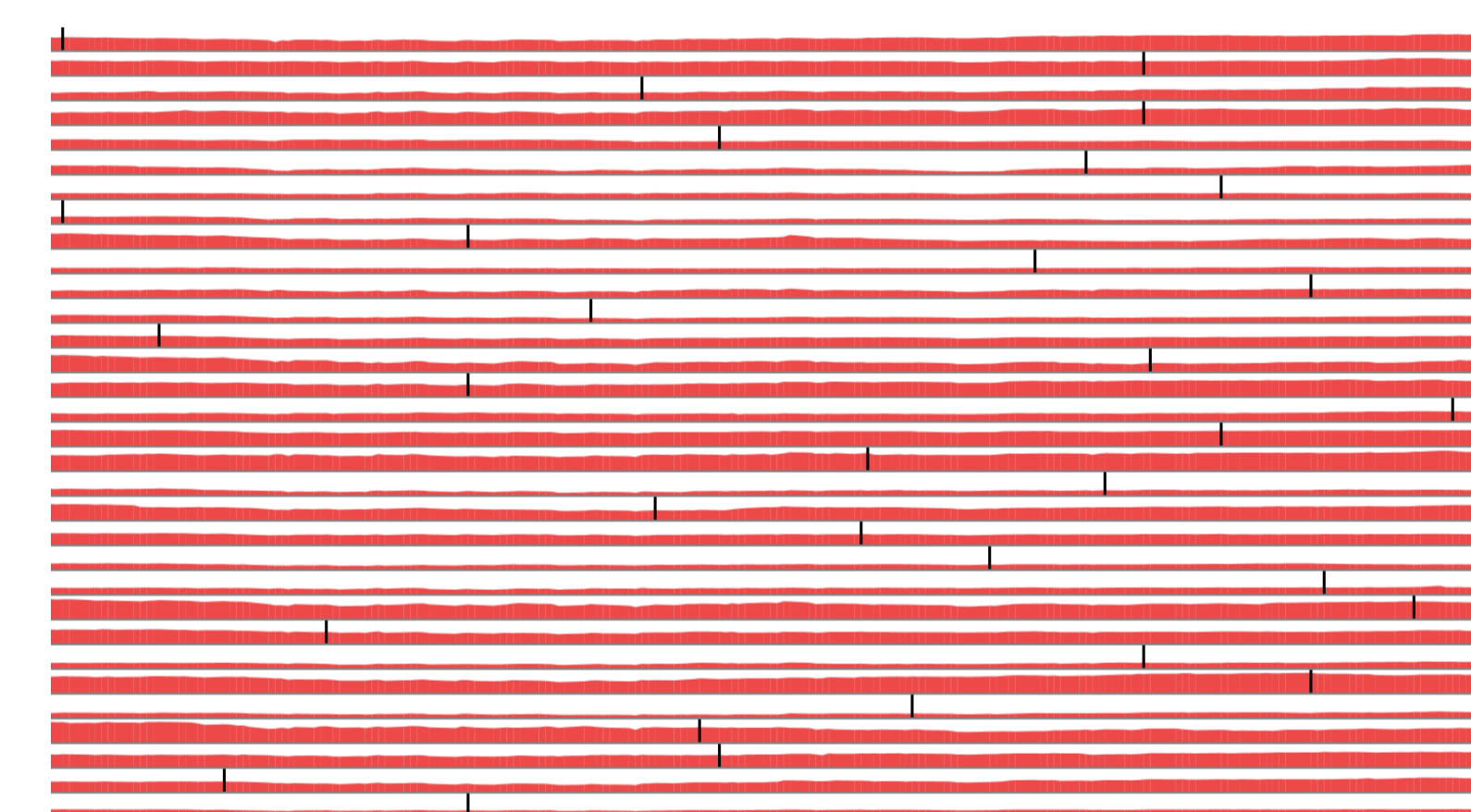
Need of interactivity

Four views of the same time series illustrating the importance of the interactive settings of y_b and z .



RLC, HG and PHG performing "Discriminate" with 32 time series

"Find which time series among 32 has the highest value at its marked time point."



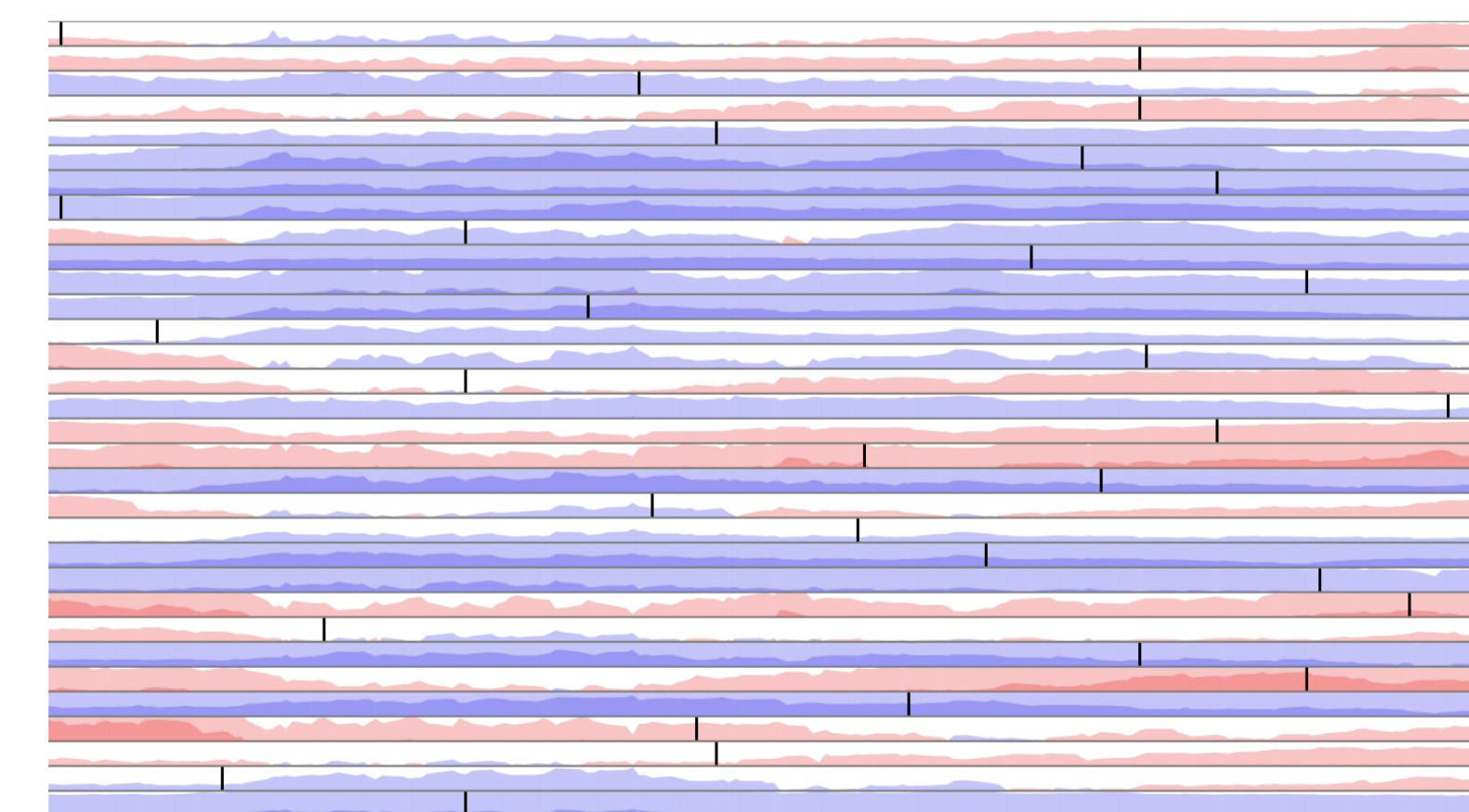
Reduced Line Charts

Accomplishing the task using RLC is highly difficult because the visual clutter involved by large numbers of time series is very high.

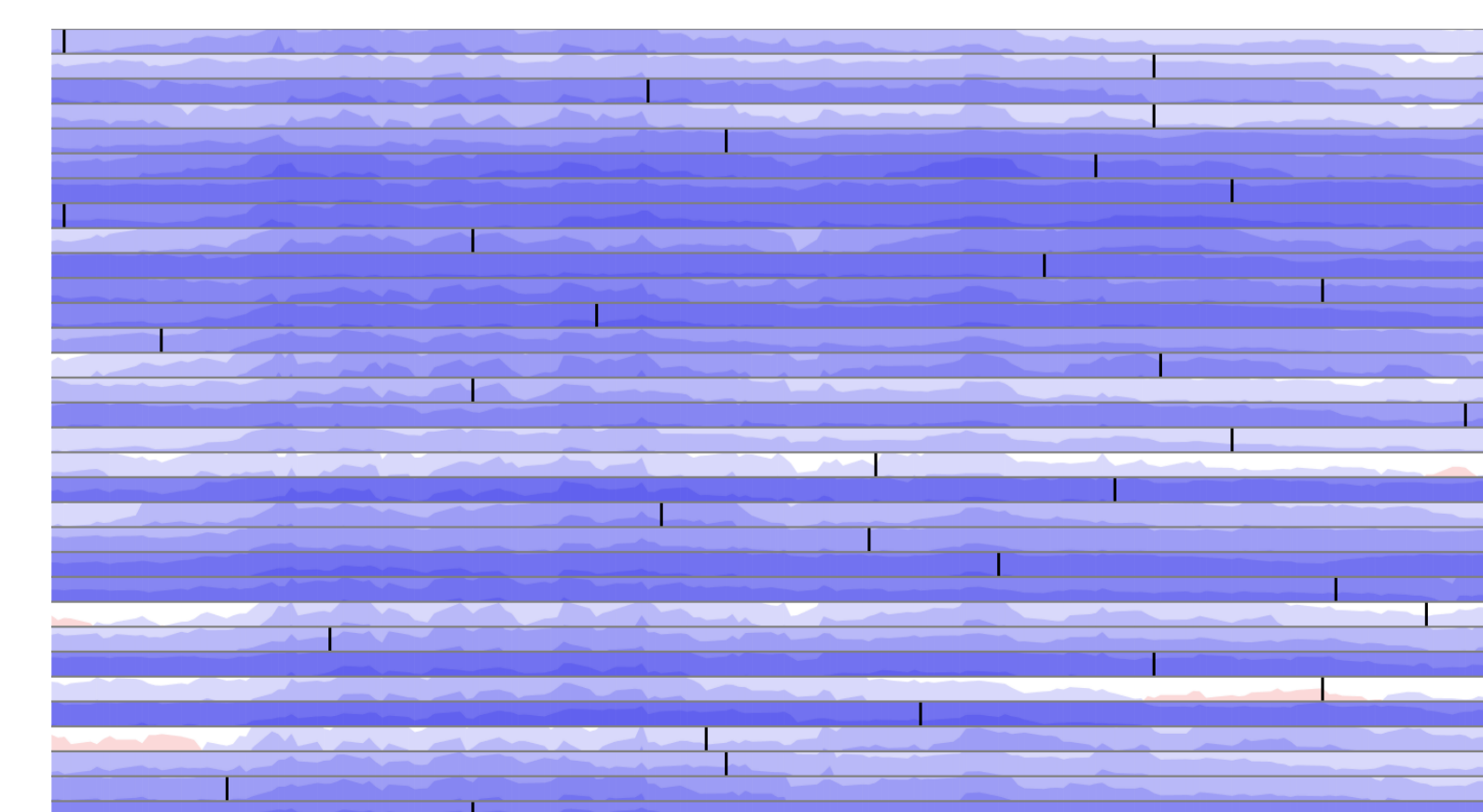
We can eliminate wrong answers but it is difficult to determine which one is the good answer, even when searching for a long time.

Horizon Graphs

Using HG with standard parameters (2 bands, $y_b = (y_M - y_m)/2$) make easier the discrimination between values: we can discard the blue values and the maximum is the highest of the most red values.



Still, we have to visually browse all the charts and can miss the right answer because the baseline separating the red and blue values is at its standard value.

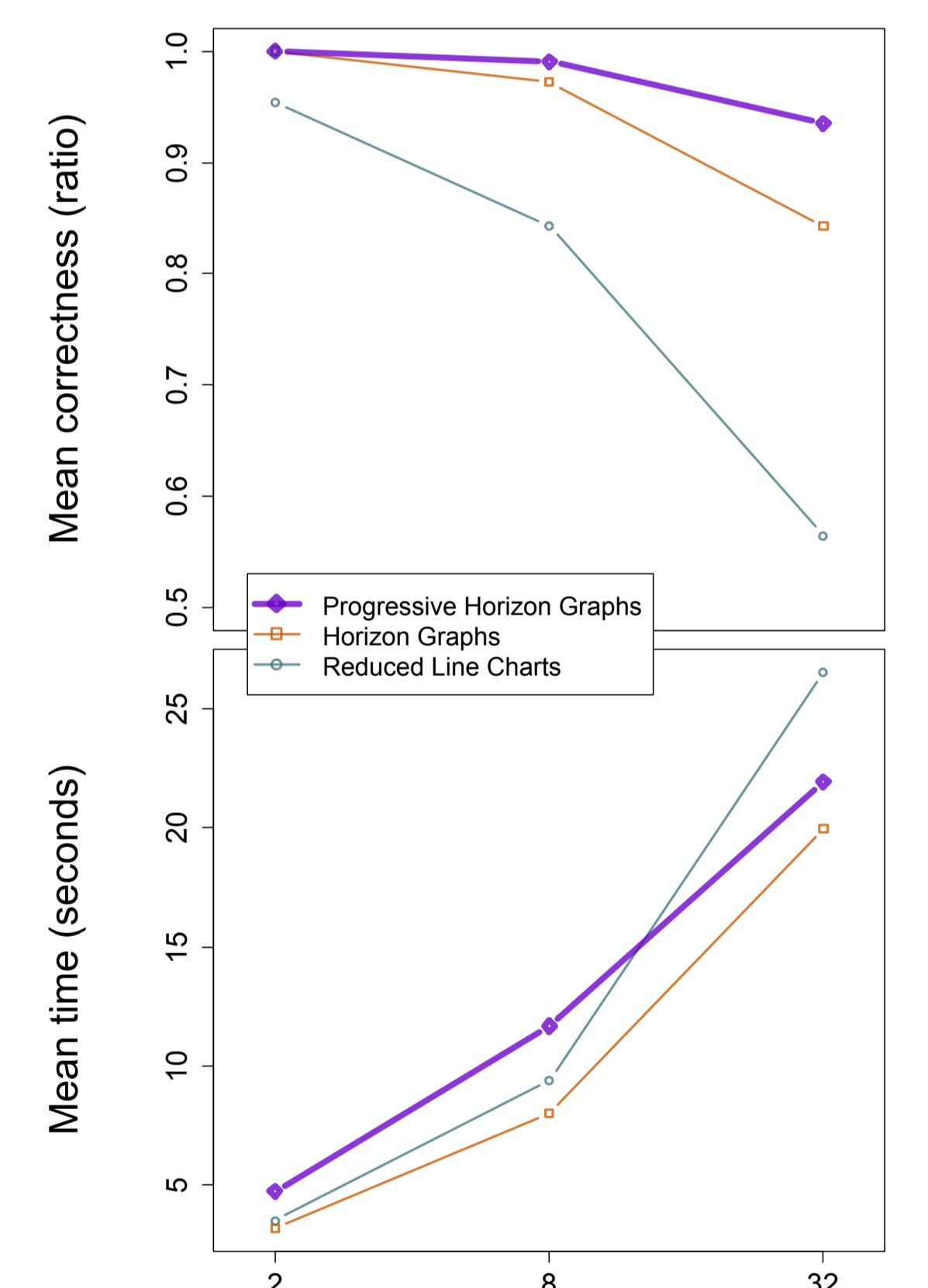


Progressive Horizon Graphs

Using PHG, we can interactively set the value of the baseline to separate in red and blue the values around a more pertinent value of interest, and set the zoom factor to an appropriate value to increase the differences in magnitude.

The answer is now clear because only one chart is colored red at its marked time point, meaning has the highest value.

Main results



- The differences between RLC, HG and PHG increase with the number of charts.
- HG perform better than RLC when the number of charts increase.
- PHG perform better than both RLC and HG when the number of charts increase, and particularly for the hardest task (discriminate) and with the highest number of time series we tested (32), where:
 - o PHG are 2.4 times more correct than RLC.
 - o PHG are 1.2 times more correct than HG.
 - o PHG have 7.5 times less error than RLC.
 - o PHG have 2.7 times less error than RLC.
 - o There is no significant difference in Time while PHG are slower than RLC and HG for low numbers of time series.
- Subjects always ranked PHG first for all tasks and all numbers of time series.