

# Topology for gaze analyses - Raw data segmentation Supplement

March 12, 2017

## Preamble

This document is a supplement to the article Hein, O. & Zangemeister, W. H. (2017). Topology for gaze analyses - Raw data segmentation. *Journal of Eye Movement Research*, 10(1):1, 1-25. The document contains interactive functionalities. The intention of the interactive part is to give the reader the opportunity to work with the ideas introduced in the main article in an intuitive way, without the burden of involved mathematics. The expectation is that the interactive capability of the Adobe<sup>®</sup> Reader<sup>®</sup> will be very helpful in illustrating complex ideas.

## General usage

The dynamic content can be activated with the buttons below the figures. The buttons are only visible in on screen reading. **Please use the buttons *Activate* and *Deactivate* to ensure smooth behavior.**

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## Spacetime coherence

Fig. 4 serves to evaluate the correspondence between the trajectory in screen space and its spacetime image representation,  $img(\mathbf{D})$ . In screen space, gaze points can be set manually with a left mouse button click. A fixation is modeled by setting several gaze points near each other. With each gaze point in screen space the time indexed matrix of combinatorial 2-point distances grows by one column and one row. Moving the mouse cursor over the matrix's image representation,  $img(\mathbf{D})$ , the corresponding ordered two-point distances are shown in screen space as an arrow (the start point in red, the end point in green). The button Grid displays a grid for  $img(\mathbf{D})$ . The grid represents the time indexing. Gaze points can also be set in “continuous” mode, i.e., moving the mouse while pressing the left mouse button. By moving the mouse with varying speed, a saccade can be modeled (it takes a little practice).

The video 1 shows the usage. Go into full screen mode by right-clicking on the video. Press Esc to return into reading mode.

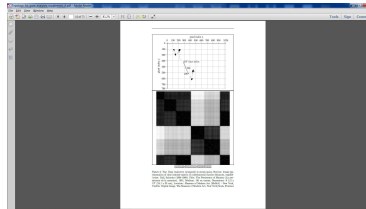


Figure 1: Video showing the interactive trajectory construction

## Visual assessment of cluster tendency

The picture viewing paradigm is used to model with the mouse a global / local scanpath pattern. A scanpath can be modeled by setting single fixation points. To model the duration the fixations's location is clicked consecutively. The number of clicks represents the duration. A “typical” scanpath while looking at a picture, i.e., central fixation bias  $\rightarrow$  global scanning  $\rightarrow$  local scanning  $\rightarrow \dots$ , can be modeled this way.

The video 2 shows the usage. Go into full screen mode by right-clicking on the video. Press Esc to return into reading mode.

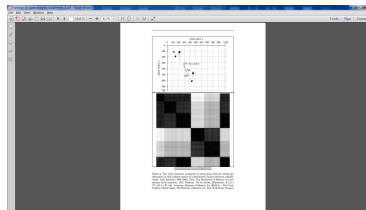


Figure 2: Video showing the scanpath construction of “looking at a painting”

## Abstract clustering

You can track your own search strategy in fig. 4. After having activated the figure with the button Activate, the button Switch will display the search screen.

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The gaze is modeled with the mouse. To model the scanpath of the search strategy every fixation is modeled with several clicks on an item. The number of clicks is the fixation's time. A spacetime pattern encoding the search strategy in Euclidean screen space will appear below. It is not unlikely for test subjects to use a random search strategy initially, and then switch to a systematic, row-by-row search strategy after a while. To reset the content deactivate and then activate the figure.

The video 3 shows the usage. Go into full screen mode by right-clicking on the video. Press Esc to return into reading mode.

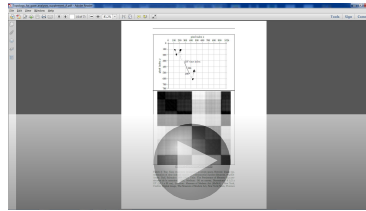


Figure 3: Video showing the scanpath construction of search paradigm

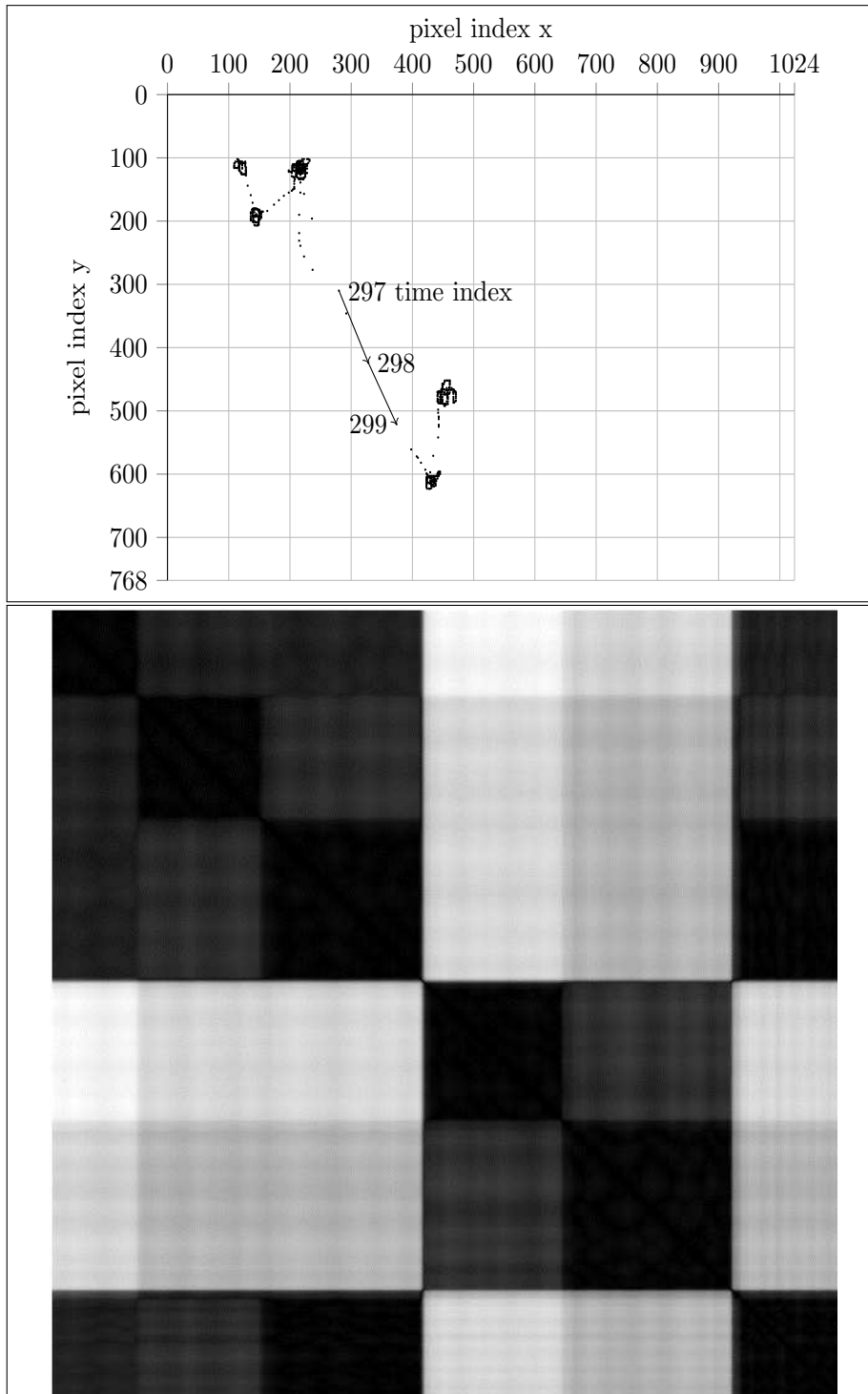


Figure 4: Top: Gaze trajectory (scanpath) in screen space, Bottom: image representation of time indexed matrix of combinatorial 2-point distances,  $img(\mathbf{D})$   
 Artist: Dalí, Salvador (1904-1989), Title: The Persistence of Memory (La persistance de la memoire), 1931, Medium: Oil on canvas, Dimensions: 9 1/2 x 13" (24.1 x 33 cm), Location: Museum of Modern Art (MoMA) - New York, Credits: Digital image, The Museum of Modern Art, New York/Scala, Florence

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## Homology for spacetime coherence

The video visualizes the "sea level raising" argument. While raising the sea level, low lying areas are flooded. At the beginning, the lakes contain many small islands. These islands disappear while further raising the level. The first level clustering is reached as soon as a coherent chain of quadratic areas along the diagonal appears. The areas communicate by small channels, so only one connected component exists. Further raising the level aggregates first level squares to second level squares along the diagonal. Off-diagonal rectangles represent a return in the scanpath. Click fig. 5 to activate it, click it again to start the video.

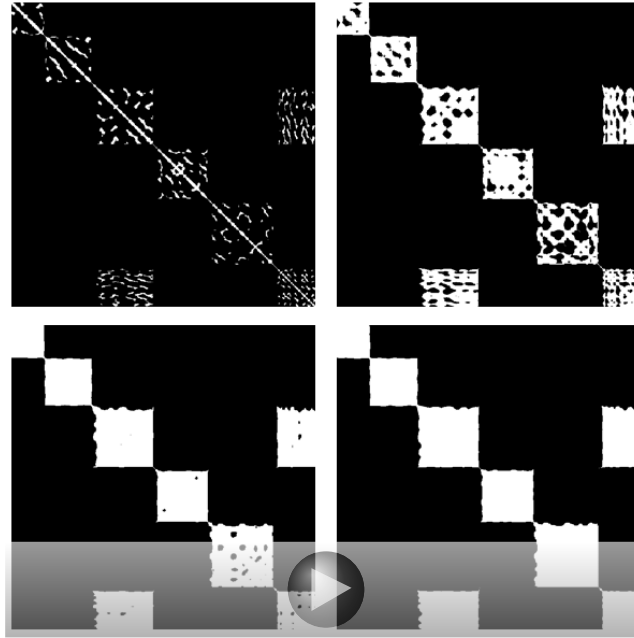


Figure 5: Raising the level shows first level clusters, i.e., fixations and a return



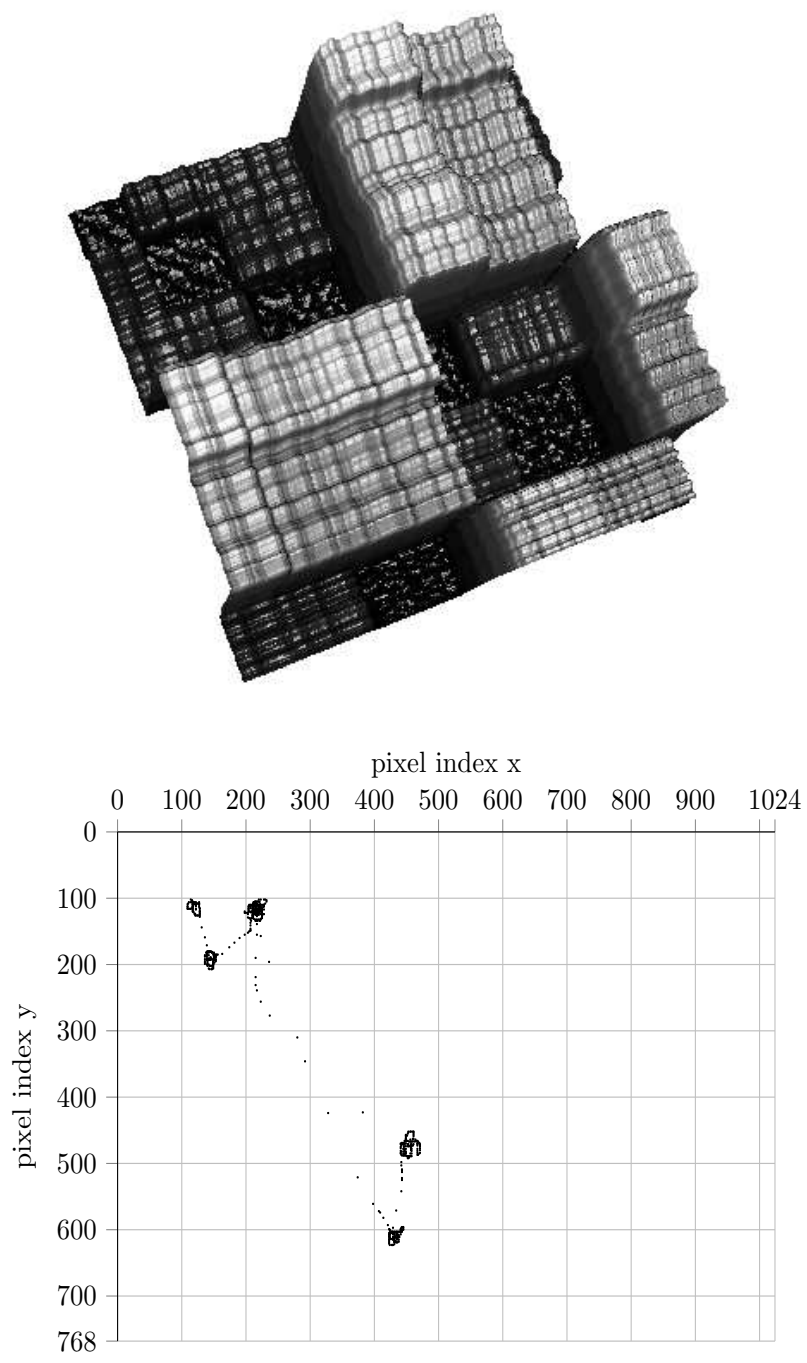


Figure 7: 3D surface plot representation of time indexed matrix of combinatorial 2-point distances and gaze trajectory