Visual Analytics on Human Body Movement Data

Applied on Healthcare

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Decision Support and Business Intelligence
IT4BI Master Thesis
Prepared at LIRMM and Université Paul Valéry Montpellier
In collaboration with NaturalPad

September 15, 2015

Outline

Motivation

(a) Kinect

(c) Wii Remote

(b) Wii Balance Board

(d) Play Station Move

Motion Sensing input devices enable players to control and interact with the game console through body movement.

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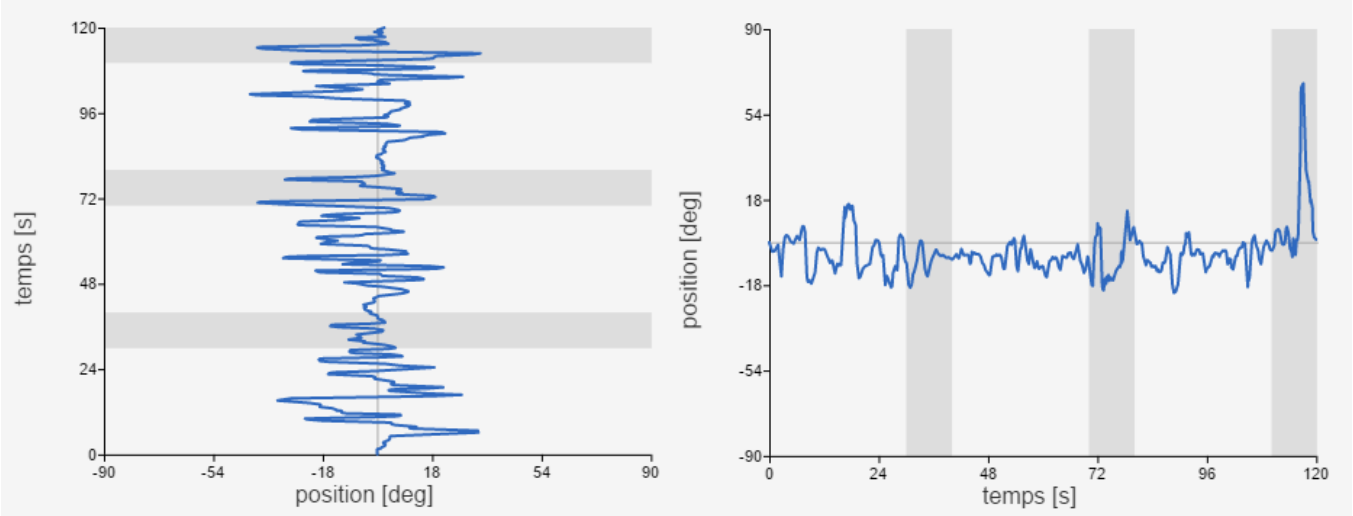
- Game missions: collect bonuses, kill enemies, avoid obstacles

Motivation



Current Visualization

Available:

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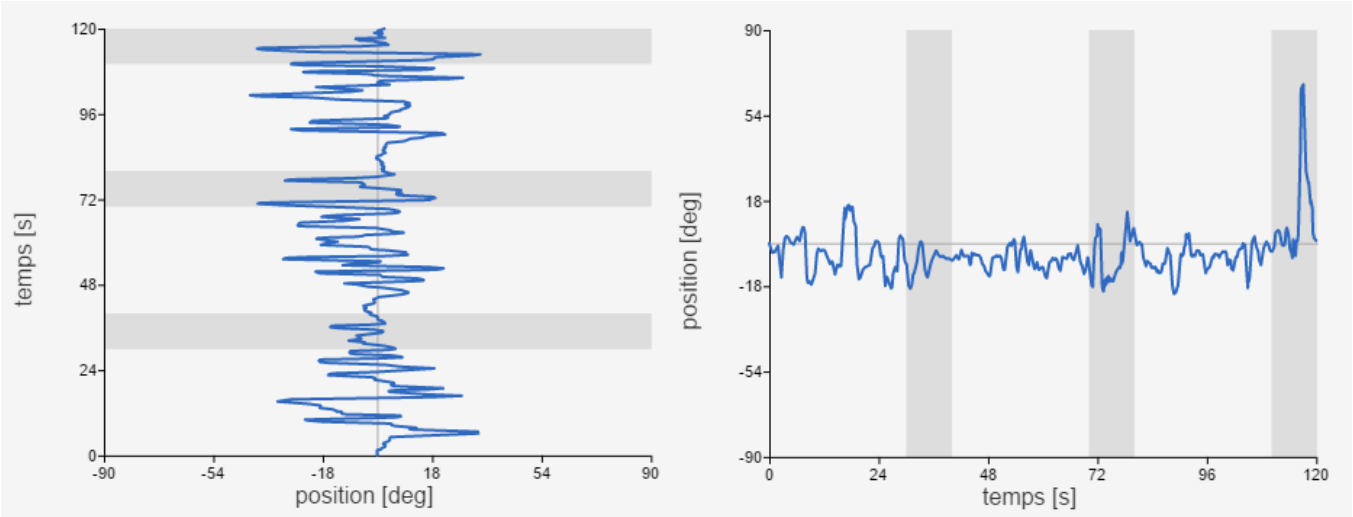

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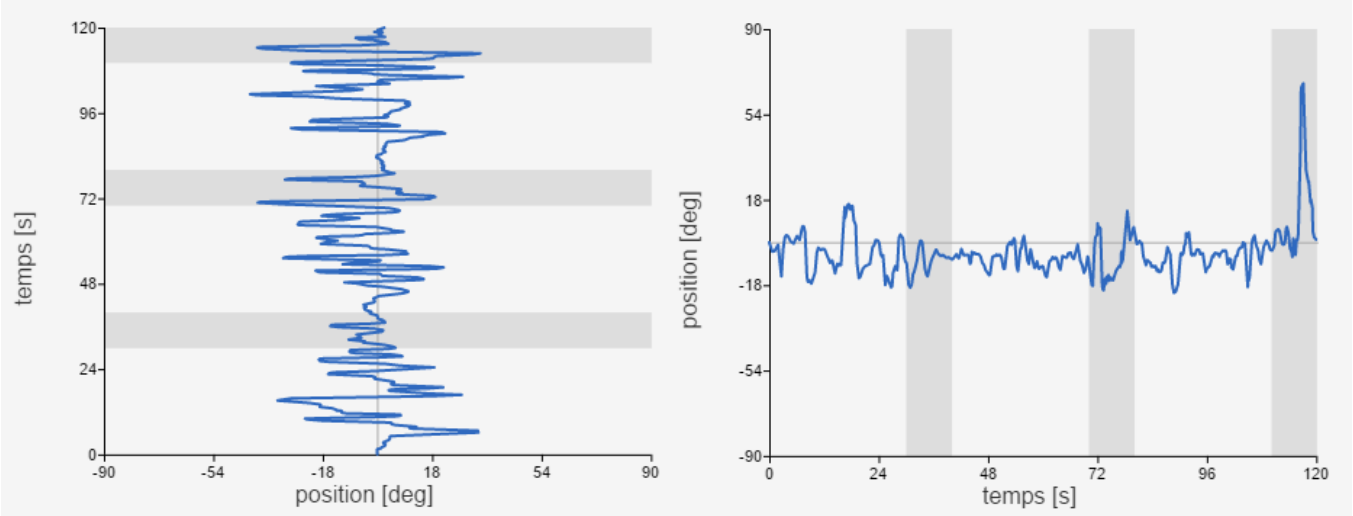

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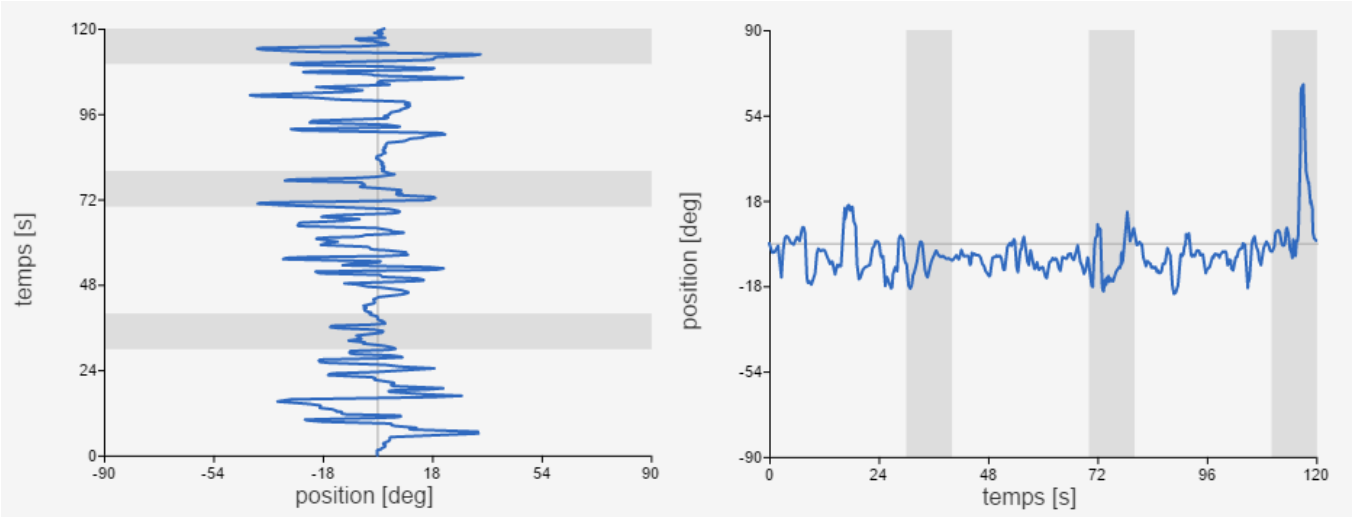

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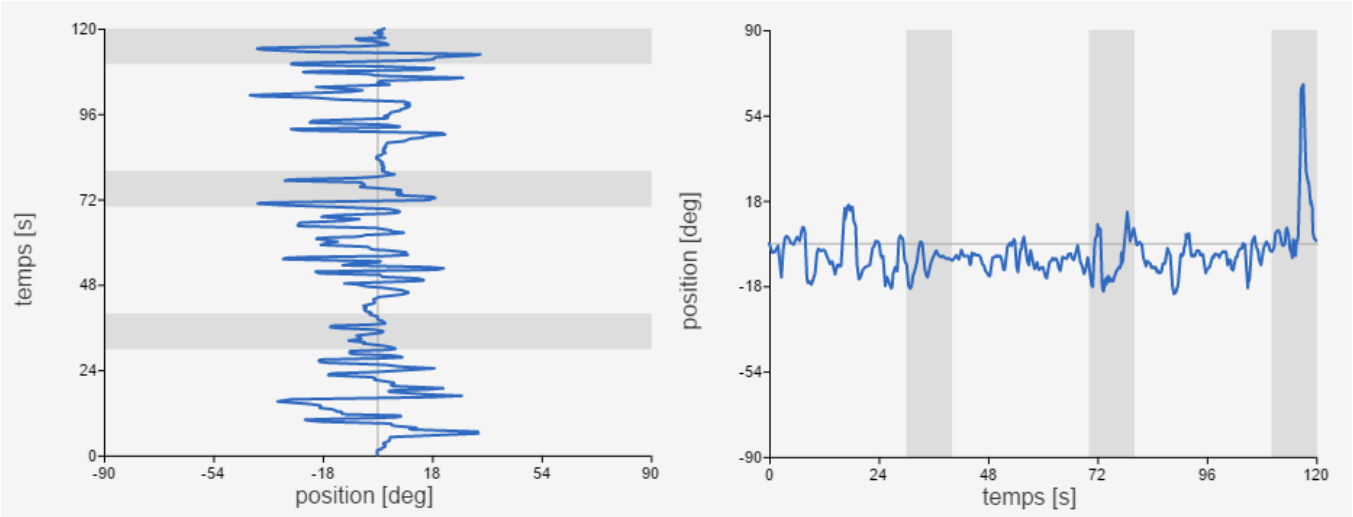

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Not available:

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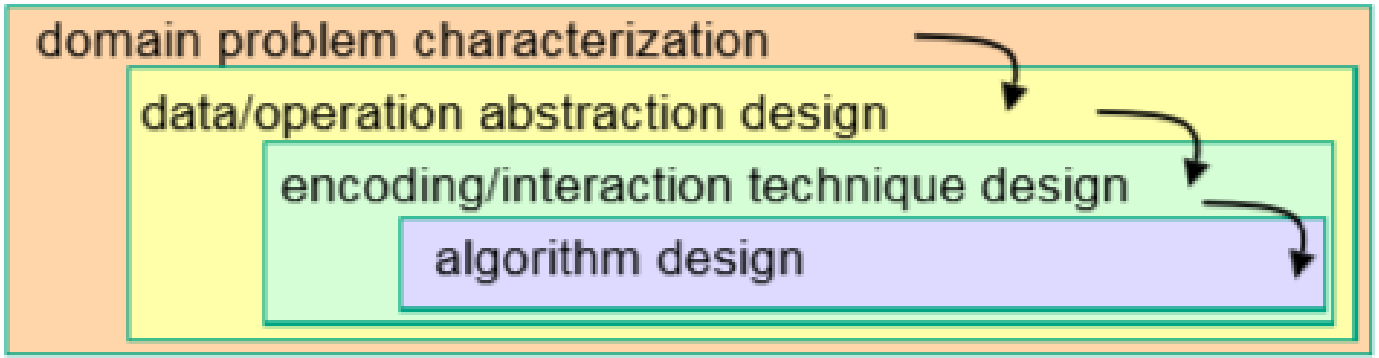
- Evolution of player's movement

Methodology



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- What kind of information needed by health professionals from the visualization (List of Tasks)

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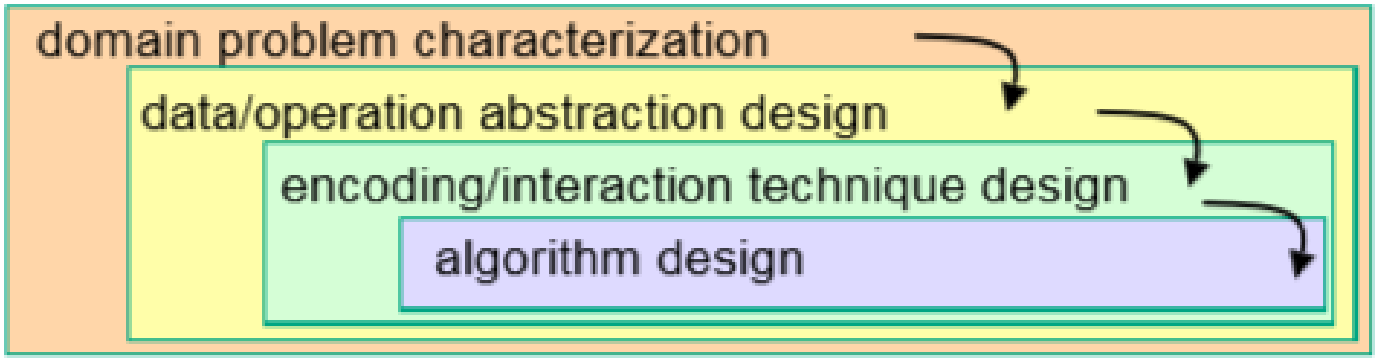

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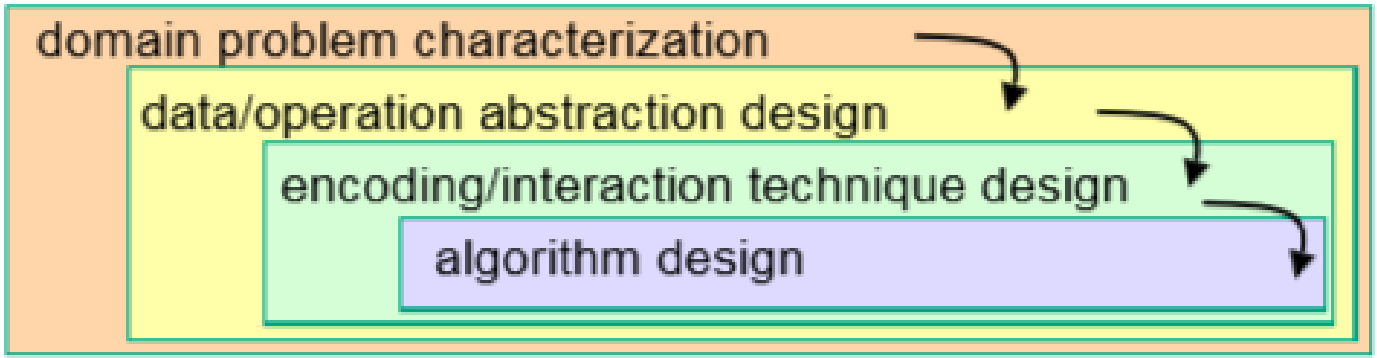

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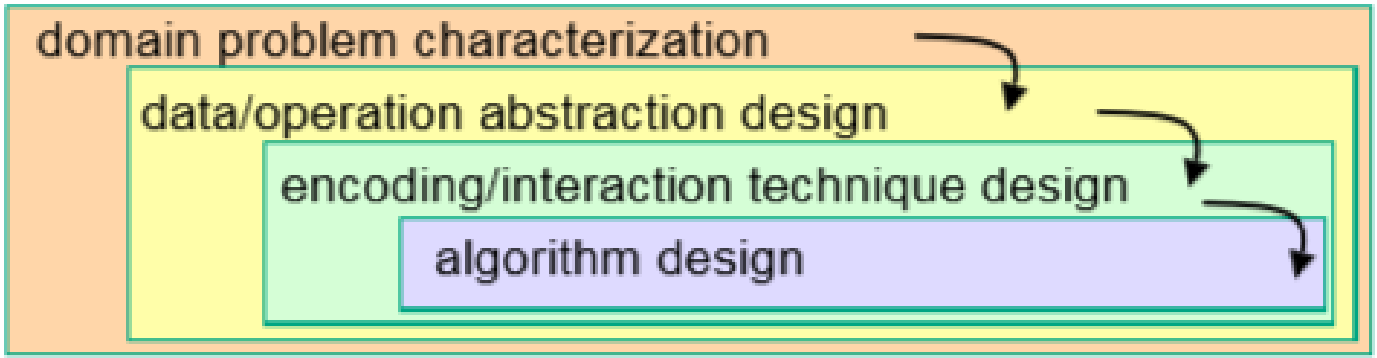

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Hammer and Planks Game Dynamic

- Game difficulty can be changed by setting:
  - **Number of objects**
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- For each pair of consecutive sequences (s_1,s_2) of S, distance is weighted sum of two distance types, represented as $f(s_1, s_2)$ and $g(s_1, s_2)$.

$$d(s_1, s_2) = \alpha f(s_1, s_2) + (1 - \alpha) g(s_1, s_2)$$

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- s'_1 and s'_2 is normalized value of s_1 and s_2 (divided by max value of each session in each section)

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$$s_1' = \begin{bmatrix} \frac{1}{2} & 1 & \frac{6}{20} \\ 1 & \frac{1}{4} & \frac{18}{20} \end{bmatrix} \; s_2' = \begin{bmatrix} \mathbf{\frac{1}{2}} & \mathbf{1} & \mathbf{\frac{1}{4}} \\ \mathbf{1} & \mathbf{\frac{1}{4}} & \mathbf{\frac{3}{4}} \end{bmatrix} \; s_3' = \begin{bmatrix} \mathbf{\frac{1}{2}} & \mathbf{1} & \mathbf{\frac{1}{4}} \\ \mathbf{1} & \mathbf{\frac{1}{4}} & \mathbf{\frac{3}{4}} \end{bmatrix}$$

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$$g_j(s_1, s_2) = \begin{cases} 0 & \text{if } s_k[i][j] = 0 \text{ for each } 0 \leqslant j < |s_k| \text{ and } k \in \{1, 2\} \\ 1 & \text{if } s_k[i][j] = 0 \text{ for each } 0 \leqslant j < |s_k| \text{ and } \exists s_p[i][j] \neq 0, \\ & k, p \in \{1, 2\},\ k \neq p \\ \dfrac{\sqrt{\sum_{i=0}^{|s_1|} (s_1''[i][j] - s_2''[i][j])^2}}{\sqrt{|s_1|}} & \text{otherwise} \end{cases}$$

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- s_1'' and s_2'' represent normalized value of s_1 and s_2 (divided by max value of each event type in each section)

Distance Calculation

$$s_1 = \begin{bmatrix} \mathbf{10} & 20 & 6 \\ \mathbf{20} & 5 & 18 \end{bmatrix} s_2 = \begin{bmatrix} \mathbf{20} & 40 & 10 \\ \mathbf{40} & 10 & 30 \end{bmatrix} s_3 = \begin{bmatrix} 10 & 20 & 5 \\ 16 & 4 & 12 \end{bmatrix}$$

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4. Recalculate distance and cluster
5. Repeat the process until there is no sections with distance below the threshold

Demo

Conclusion

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  - Visualize log data related to skeleton movement

Question


thank you!

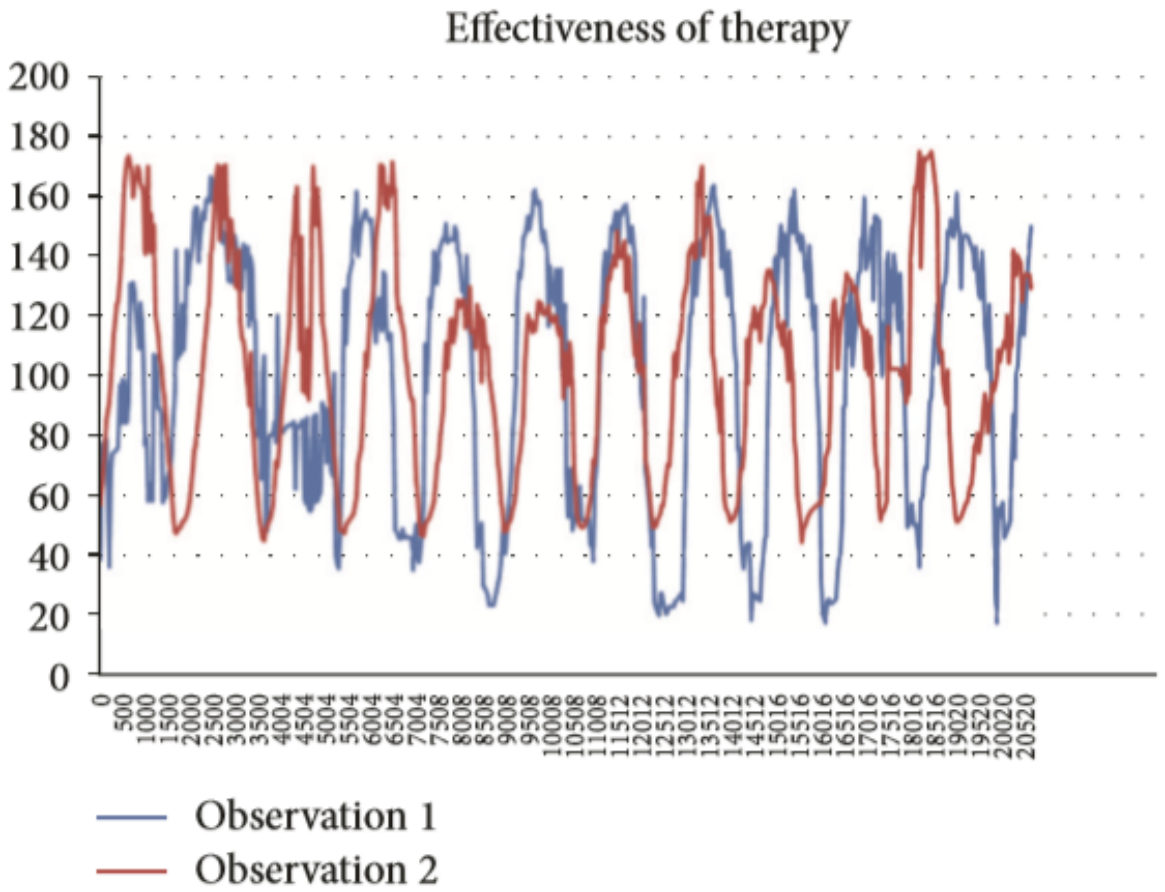
Visualization Requirements

Tasks related to a session of a particular player:
(T1.1) visualize and be able to compare the number of events within the same or among different event type at a given x area (Q1)(Q2).
(T1.2) visualize and be able to compare the number of events and its screen speed of the same or among different event type at a given x area (Q1)(Q2)(Q3).
(T1.3) select and visualize the number of events for a certain object at a given x area (Q1)(Q2).
(T1.4) select and visualize the number of events and its screen speed for a certain object at a given x area (Q1)(Q2)(Q3).

Visualization Requirements

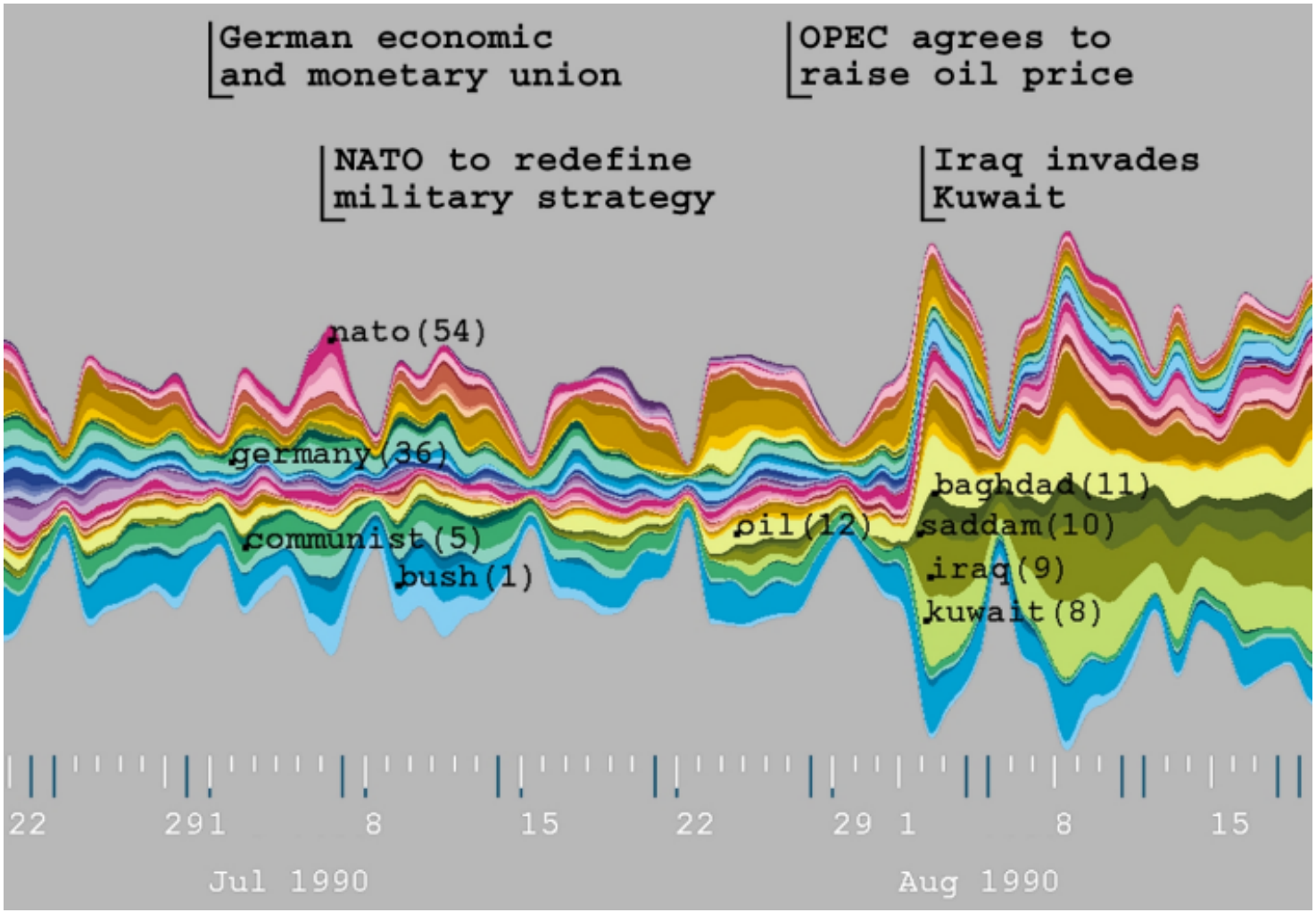
Tasks related to the summary of all sessions of a player:
(T2.1) visualize, navigate and be able to compare the evolution of number of events throughout all sessions within a certain x area.(Q4)(Q5).
(T2.2) select and visualize the number of events of a certain event type in a certain x area throughout all sessions (Q4)(Q5).
(T2.3) visualize, navigate and be able to compare the distribution of a certain number of events over x area among all sessions(Q4)(Q5).
(T2.4) select and visualize the distribution of certain number of events over x area for a certain event type throughout all sessions (Q4)(Q5).
(T2.5) extract and visualize similar pattern of number of events evolution throughout all sessions over a certain x area (Q4)(Q5).

Visualization of Serious Game Result



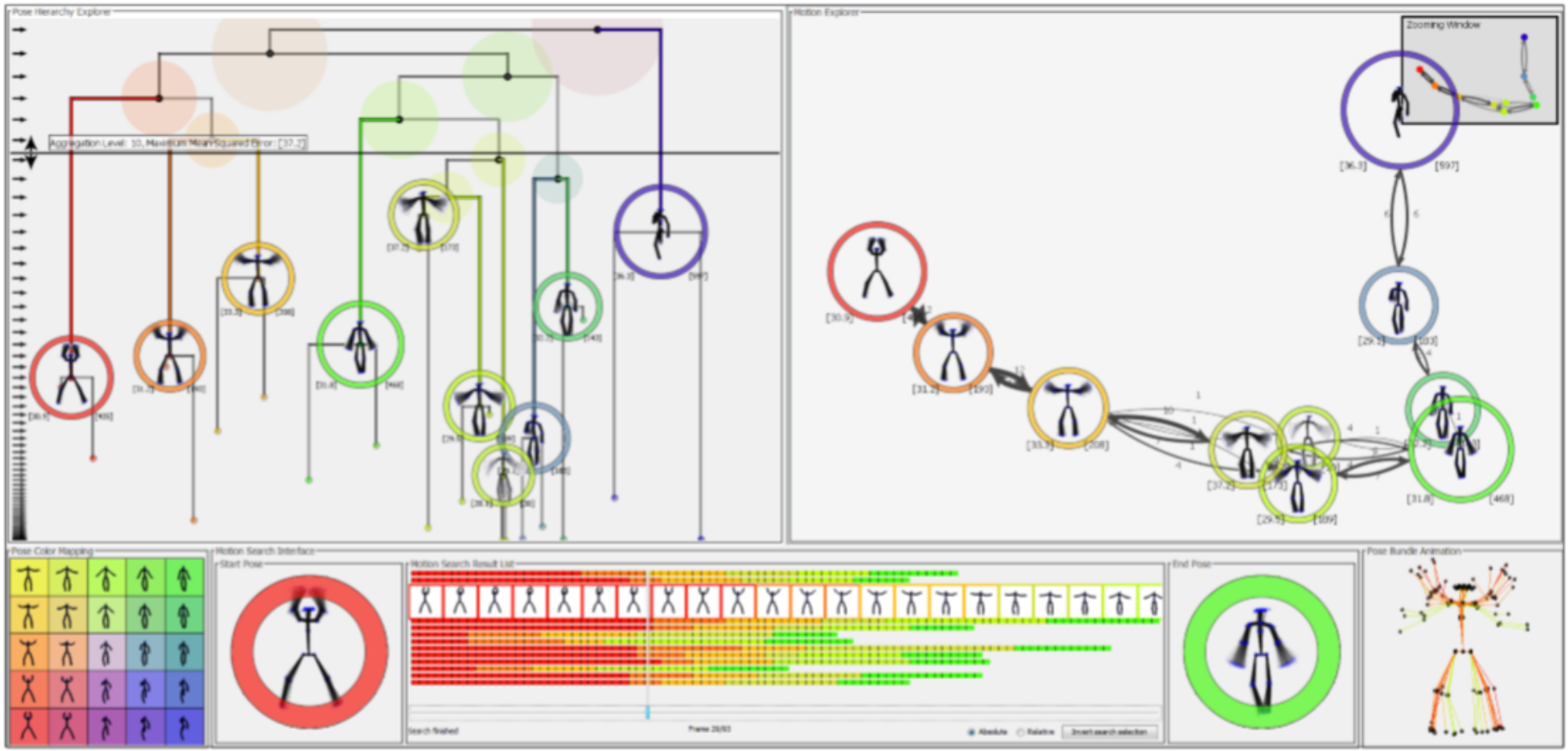
Line Chart depicting degree of forearm movement over time

Visualization of Time Series Data



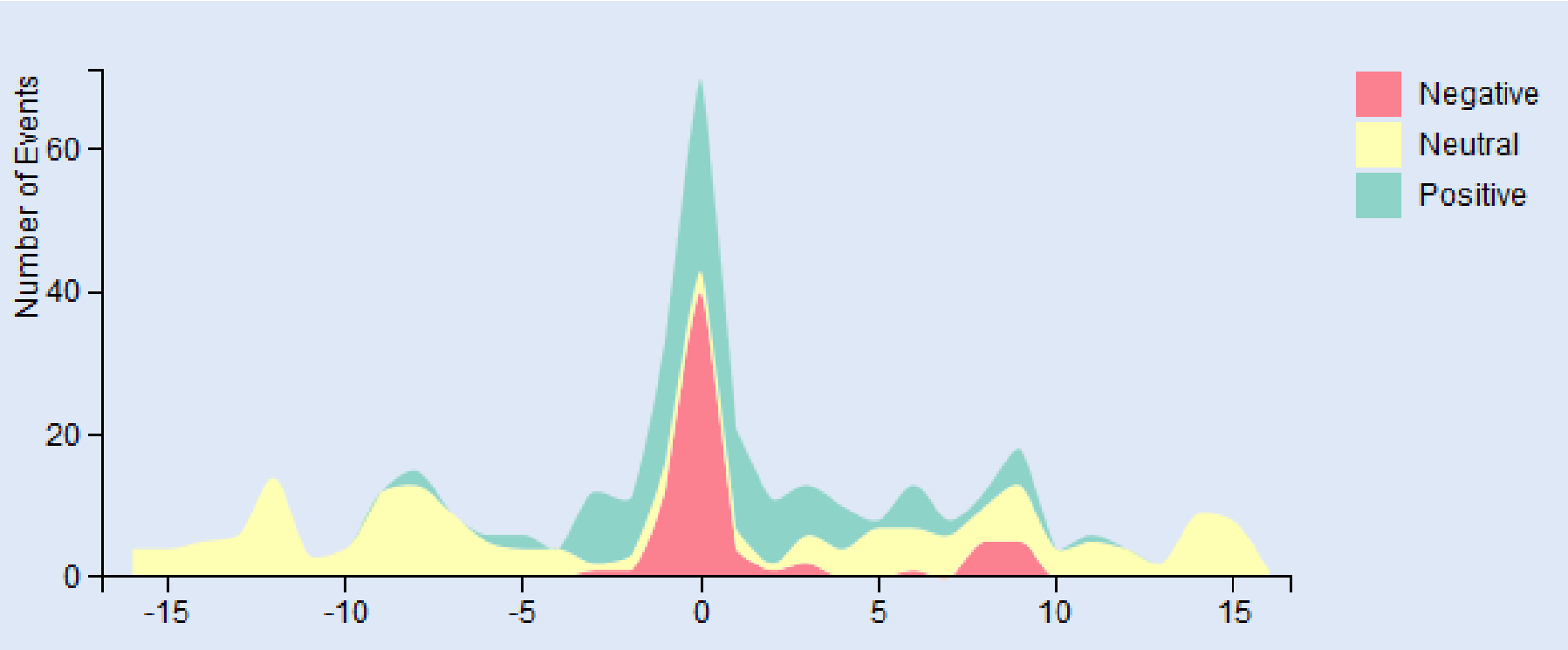
Theme River

Visualization of Movement Data



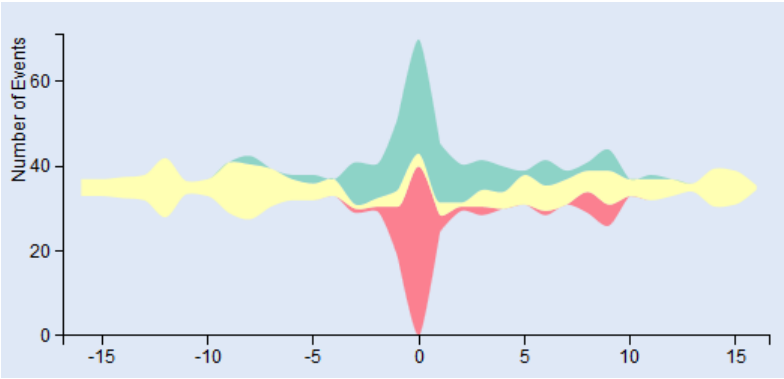
Motion Explorer

Session Visualization - Stacked Graph (T1.1)

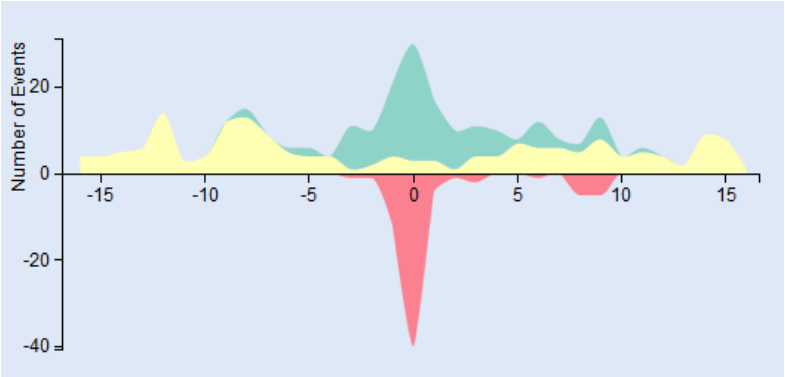


Stacked Graph depicting number of events over x axis

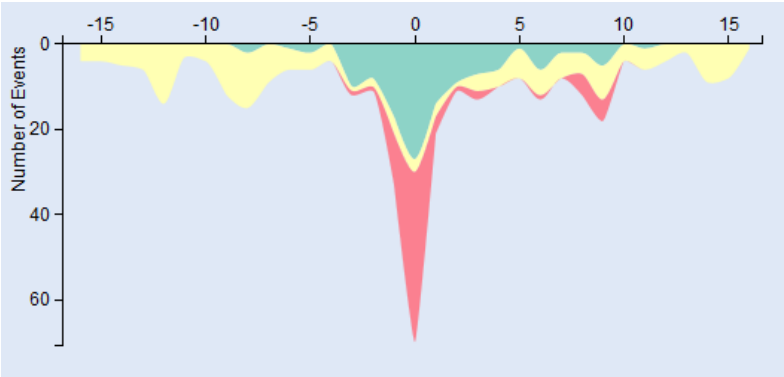
Session Visualization - Stacked Graph Layout



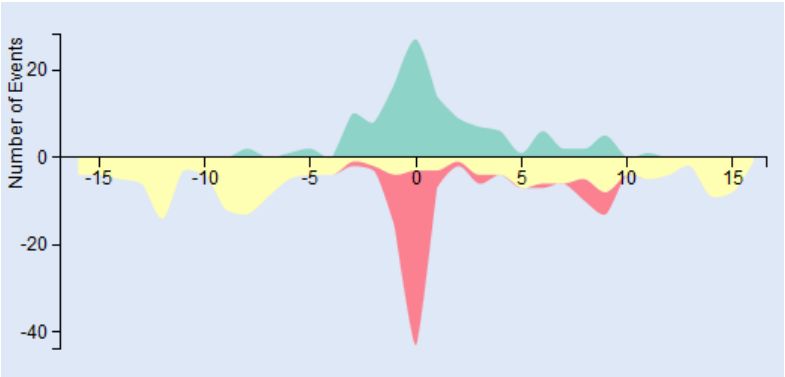
Silhouette



Neutral-Negative

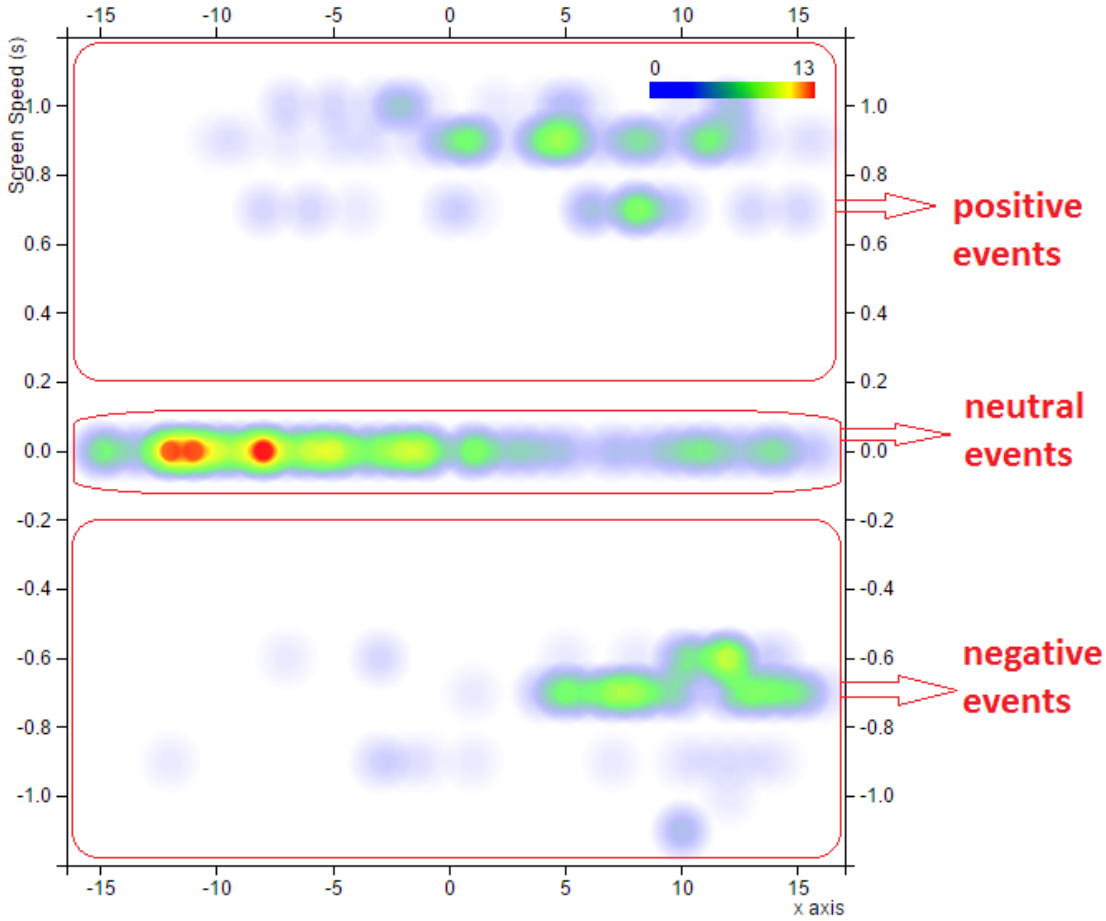


Positive



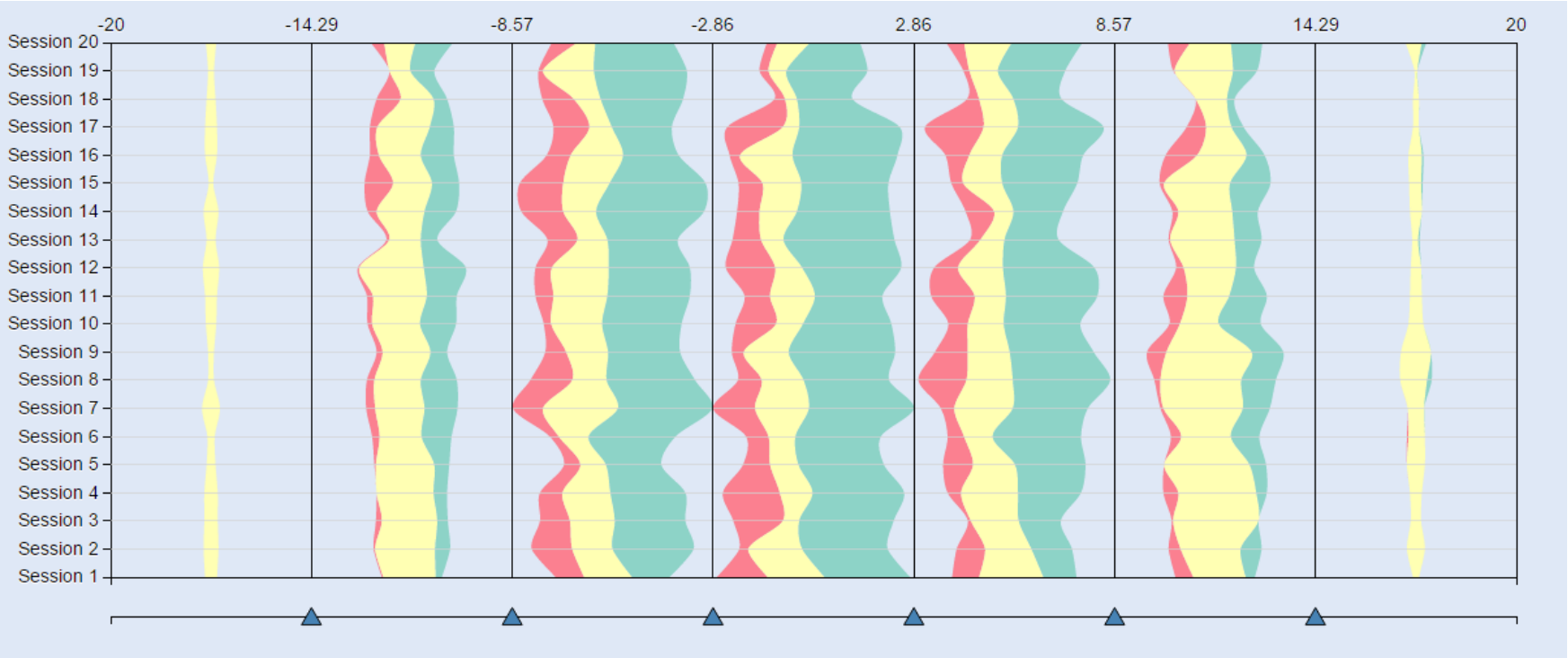
Positive-Neutral

Session Visualization - Heatmap (T1.2)



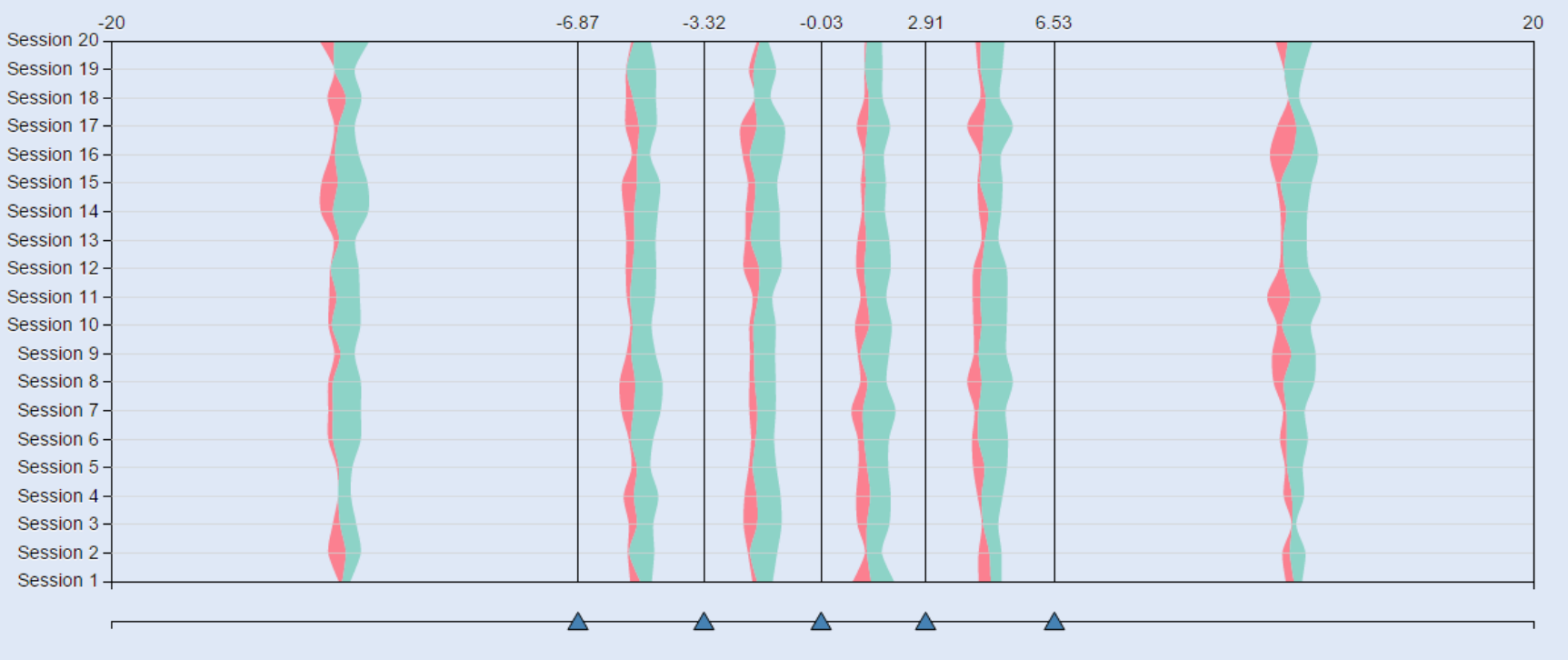
Heatmap depicting number of events and screen speed over x axis

Summary Visualization by range of x-area (T2.1)



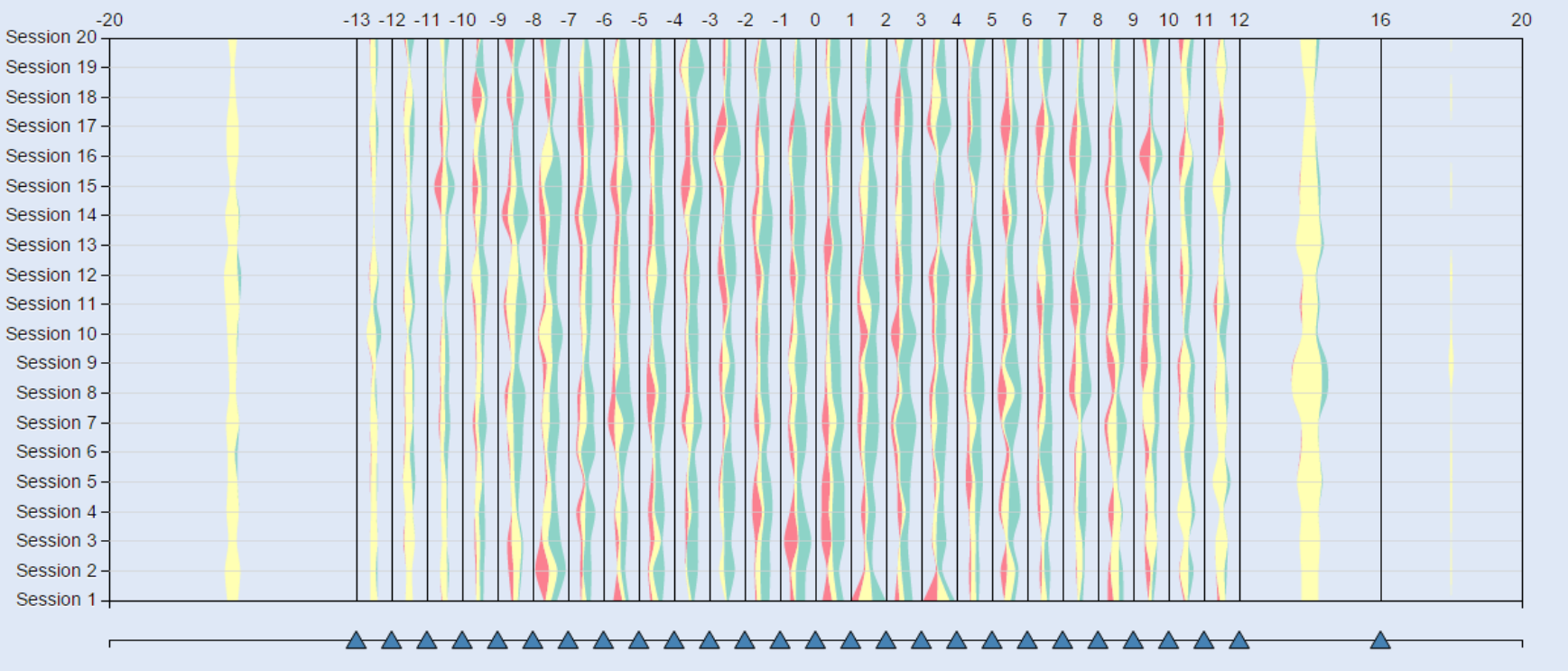
Summary Visualization by range of x-area: each section has the same x-range

Summary Visualization by number of events (T2.3)



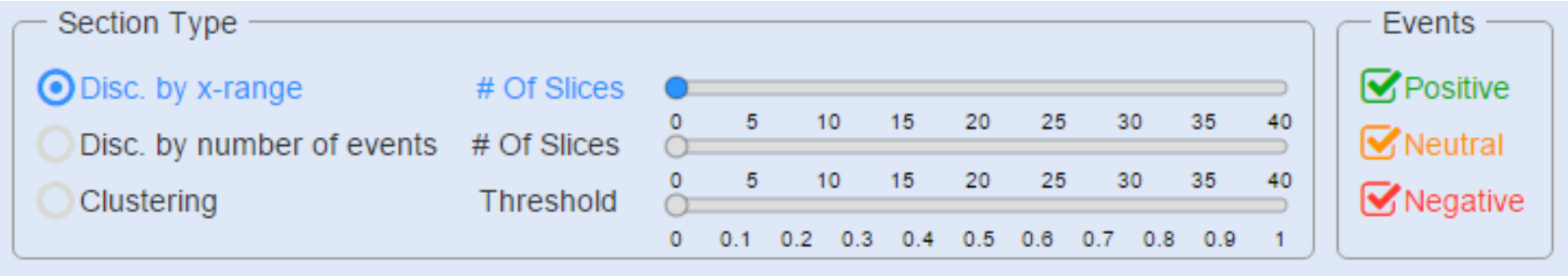
Summary Visualization by number of events: each section has the same number of positive and negative events

Summary Visualization by clustering (T2.5)



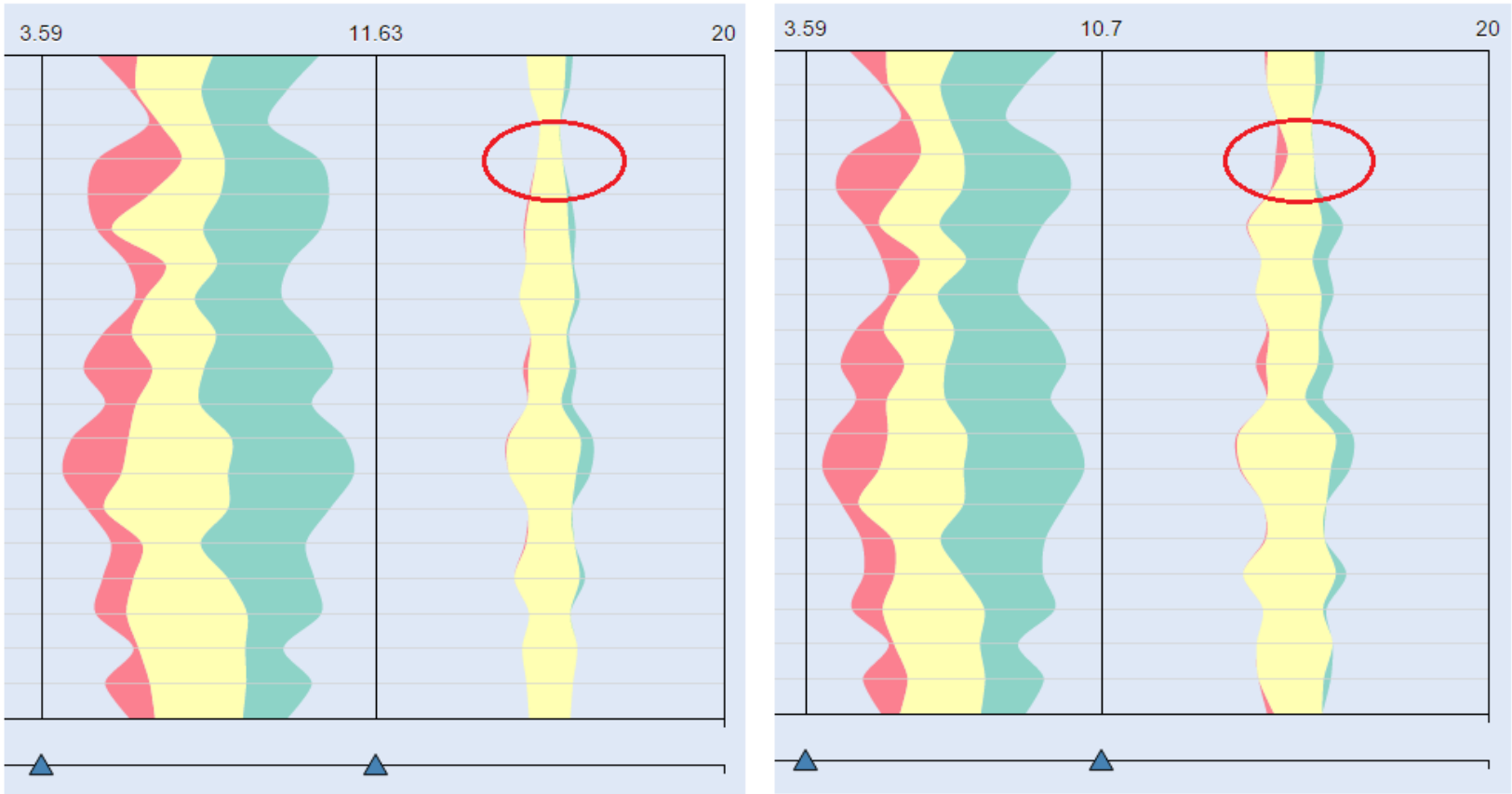
Summary Visualization by clustering: each section has the similar movement pattern

Summary Visualization - Interaction Technique(T2.2,T2.4)



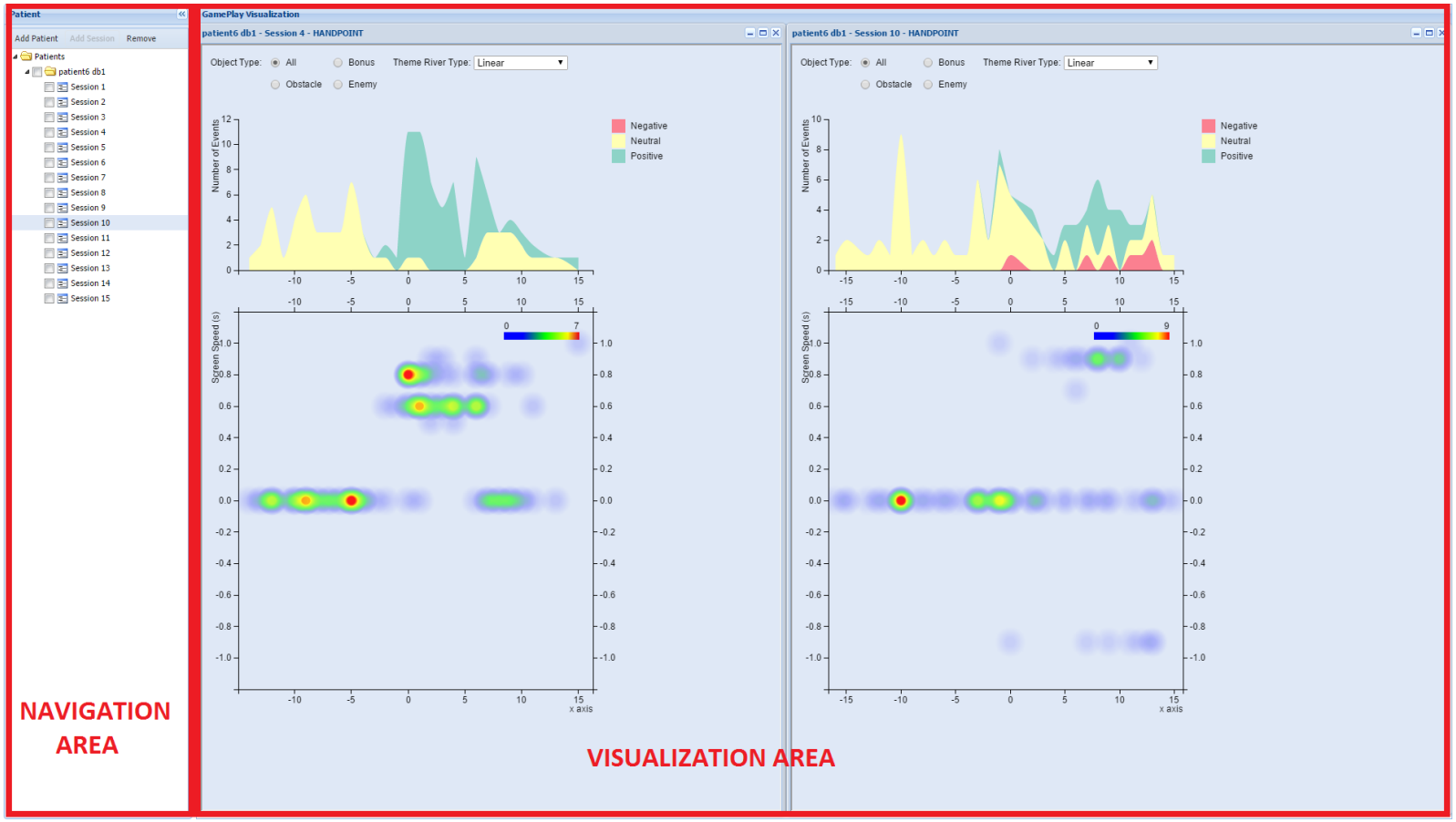
Interaction bar allows user to choose which event type to show and change input using sliders

Summary Visualization - Interaction Technique



By dragging section line or triangle symbol, user can highlight movement pattern

General Interface



Interface is divided into two areas: navigation area and visualization area

Case Study and Demo

- Data set is acquired from NaturalPad
- Data set is of game played by patient with pathology(type of pathology unknown)
- Case study using HandPoint exercise, consists of 6 sessions