

OntoCare™ is a software tool which enables users to measure the impact or effectiveness of therapy (surgery, implant, drugs) based on pre and post-treatment data. When analyzing patients suffering from heart disease, raw ECG data is used to determine the effectiveness of therapy. An example of such data is illustrated below.

	A	B	C	D	E	F	G	H	I	J	K	L
1	I	II	III	aVR	aVL	aVF	V1	V2	V3	V4	V5	V6
2	-4.00E-02	8.30E-02	6.00E-02	6.50E-02	-1.03E-01	1.10E-01	2.50E-02	-3.70E-02	5.00E-02	-5.50E-02	-4.50E-02	-1.53E-01
3	-4.00E-02	8.30E-02	6.00E-02	6.50E-02	-1.03E-01	1.10E-01	2.50E-02	-4.00E-02	4.50E-02	-5.80E-02	-4.50E-02	-1.55E-01
4	-4.30E-02	8.50E-02	5.80E-02	6.30E-02	-1.00E-01	1.08E-01	2.80E-02	-4.30E-02	4.50E-02	-6.30E-02	-5.00E-02	-1.55E-01
5	-3.50E-02	8.80E-02	5.80E-02	6.00E-02	-1.00E-01	1.10E-01	2.50E-02	-4.30E-02	4.50E-02	-6.00E-02	-5.20E-02	-1.53E-01

Figure 1. Example of raw ECG data.

In particular, data from two electrocardiograms is used to quantify therapy effectiveness. The parameters values correspond to the mV tensions recorded at each channel. The first data set (left) has been recorded before treatment, while the second one at follow-up (right). An example is illustrated below.

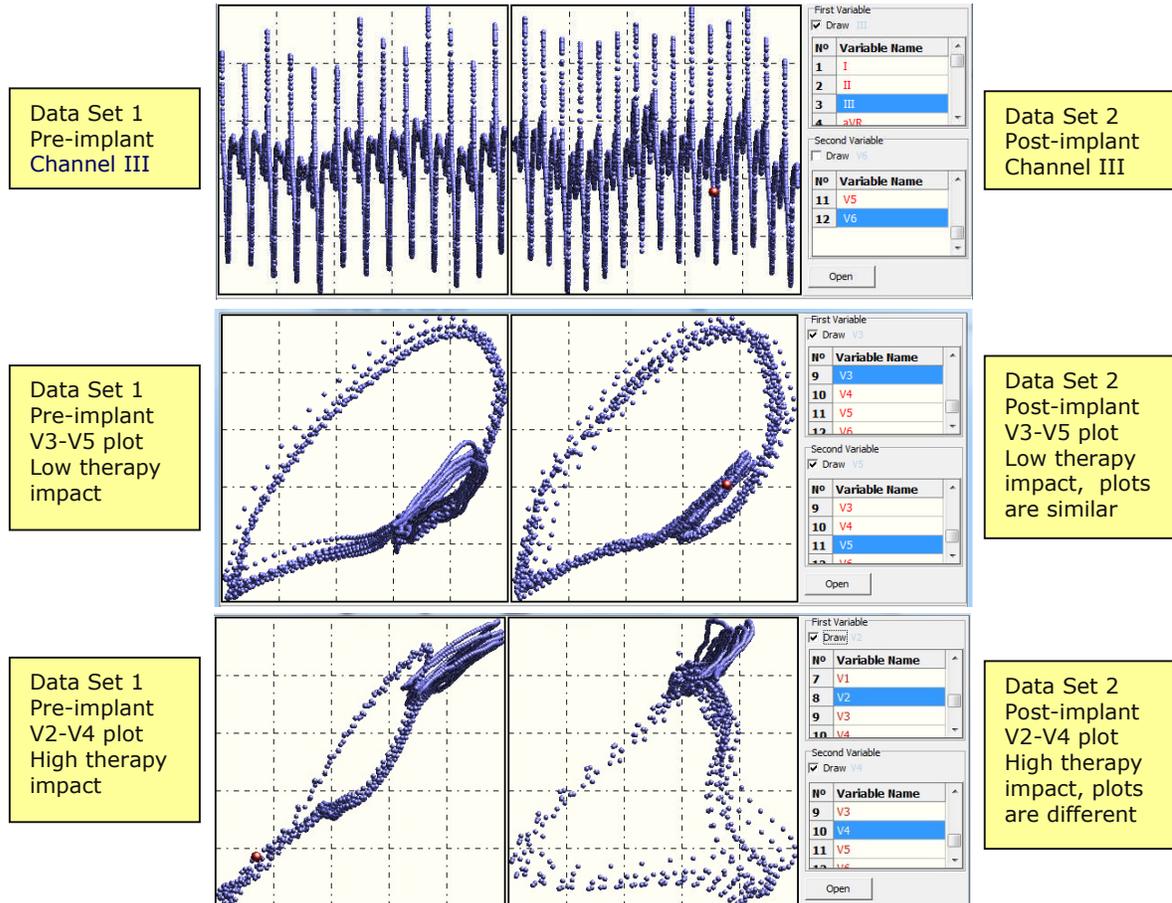
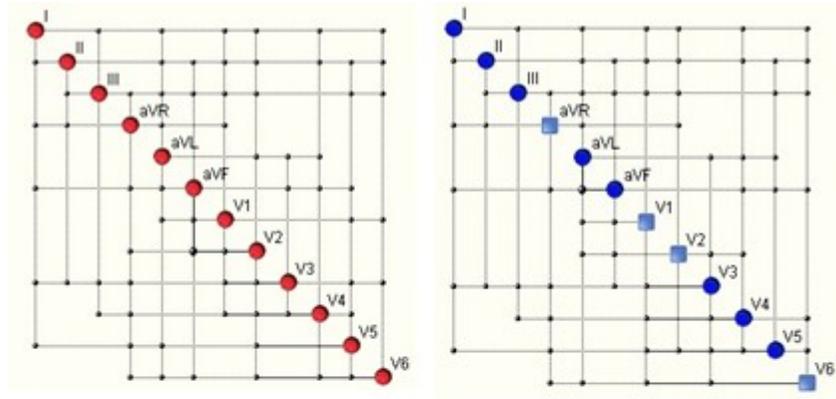


Figure 2. Example of pre and post-treatment ECG (channel III in top plot) and V3-V5 (low impact) and V2-V4 (high impact) scatter plots.

The first step in the analysis is to establish for each ECG the so-called System Map is illustrated below. The map is composed of nodes (variables) – arranged along the diagonal – links, and connectors. When



Low therapy impact, maps have almost identical topology



High therapy impact, map topology differs significantly

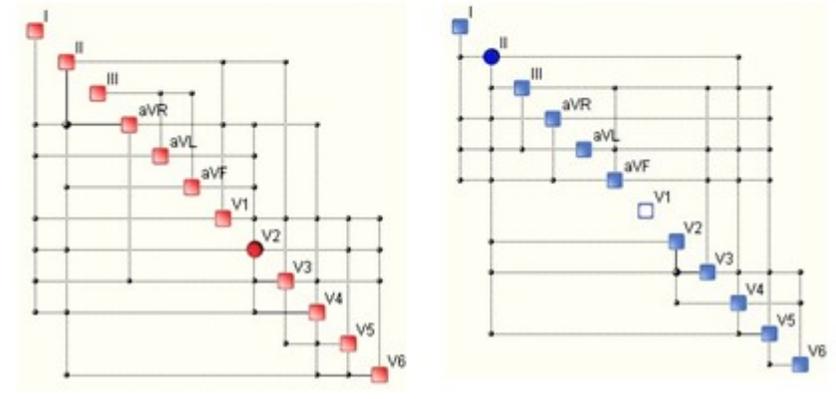


Figure 3. ECG System maps. Two cases are illustrated: low therapy impact (above) and high impact (below).

A new means of determining the importance (footprint) of a variable in a multi-dimensional data set is via the Complexity Profile. The profile provides a breakdown of the total system complexity, which is measured in bits into components. This done using a knock-out technique. An example is shown below.

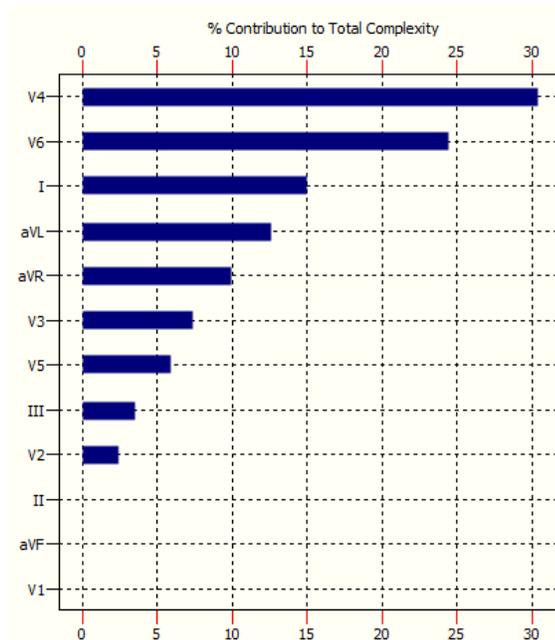


Figure 4. Example of Complexity Profile of an ECG

The Complexity Profiles quantifies what percentage of the total information contained in a data set is lost if that particular channel is neglected (removed). Given that the profile is computed based on a knock-out technique, the sum of these contributions does not necessarily sum up to 100%.

The impact of therapy is measured as the topological distance of the two System Maps. In other words, OntoCare™ compares the topologies of the two System Maps and relates their difference to the first System Map which represents the patient in a pre-therapy situation. The Data Similarity Index is computed as  $DSI = (1 - \frac{\|T\alpha - T\beta\|}{\|T\alpha\|}) \times 100\%$ , where  $T\alpha$  and  $T\beta$  represent, respectively, the pre and post-treatment ECG adjacency matrices (System maps). Because adjacency matrices represent the ECG topology, the DSI is a measure of topological similarity. An example of Data Similarity Index for a particular case is shown below.

Complexity Data Set 1 (bas\_2\_10k\_ECG): 25.48  
 Complexity Data Set 2 (pos\_2\_10k\_ECG): 15.91  
  
 Data Set Similarity: 36.81 %  
  
 Overall Level of Correlation: Low

Figure 5. Data Set Similarity Index

In the example under consideration, the Data Set Similarity Index is equal to 36.8%. This means that the topological distance of the two System Maps (corresponding to pre and post-treatment ECGs) is 63.2%. This is the measure of the effectiveness of therapy in the case in question. If the Data Similarity Index is high, say around 80-90%, one may conclude that the therapy has low impact (10-20% or less). In the case under consideration, the impact or effectiveness of therapy may be considered as high.

The Delta Profile provides a quantitative breakdown of the topological distance between the two System Maps (ECGs). In particular, the contribution of each variable (channel) to the said distance is provided. In the above example, the distance is found to be 63.2%. The Delta Profile indicated below shows in what measure which channel contributes to this distance.

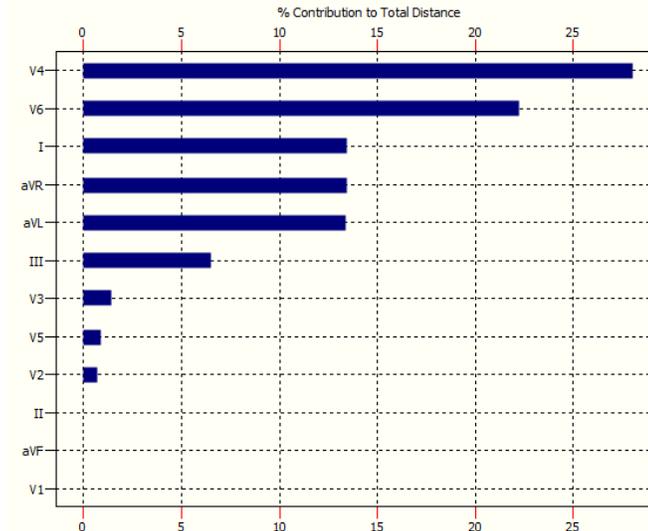


Figure 6. The Delta Profile

For example channel V4 – the biggest contributor - represents almost 30% of the mentioned therapy impact of 63.2%. The second most responsive channel is V6, while channels V3, V2, II, aVF and V1 do not reflect the therapy. The Delta Profile is also computed based on a knock-out technique.