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Big Data Visualisations

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NCRG

Overview

- Why visualise data?
- How we can visualise data
- Big Data Institute

What is Visualisation?

- Goal of visualisation is to present data in a human-readable way.
- Visualisation is an important tool for developing a better understanding of large complex datasets. It is particularly helpful for users who are not specialists in data modelling.
  - Detection of outliers.
  - Clustering and segmentation.
  - Aid to feature selection.
  - Feedback on results of analysis: seeing what you are doing.
- Two aspects: data projection and information visualisation.

Data projection

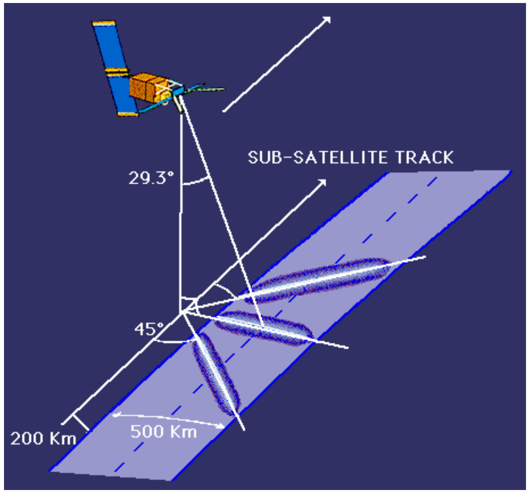
- The goal is to project data to a lower-dimensional space (usually 2d or 3d) while preserving as much information or structure as possible.
- Once the projection is done standard information visualisation methods can be used to support user interaction. These may need to be modified for Big Data.
- The quantity and complexity of many datasets means that simple visualisation methods, such as Principal Component Analysis, are not very effective.

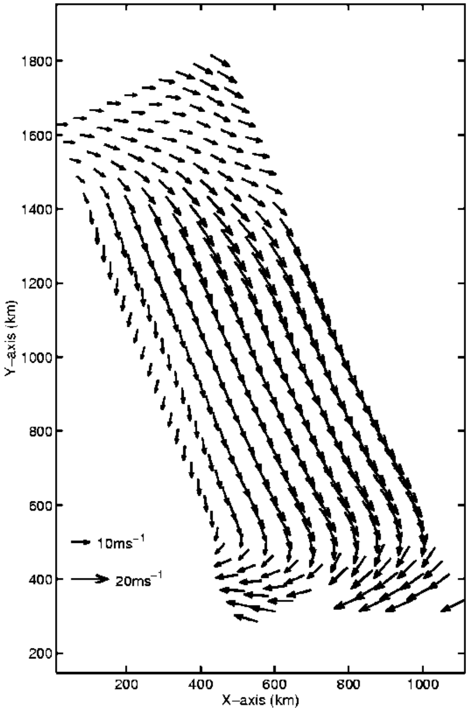
Information Visualisation

- Shneiderman’s mantra: Overview first; zoom and filter; details on demand.
  - Overview provided by projection.
  - Zooming on plots.
  - Filtering by user interaction; e.g. specify pattern of values that is of interest.
  - Details by providing local information.

Hidden Knowledge

- Understanding the vast quantities of data that surround us is a real challenge
- We can understand more of it with help. Machine learning is the computer-based generation of models from data.
- Parameters in the model express the hidden connection between inputs and predictions.





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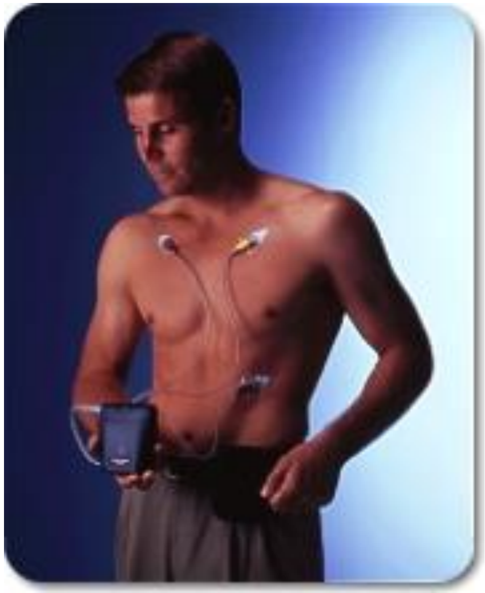
Uncertainty

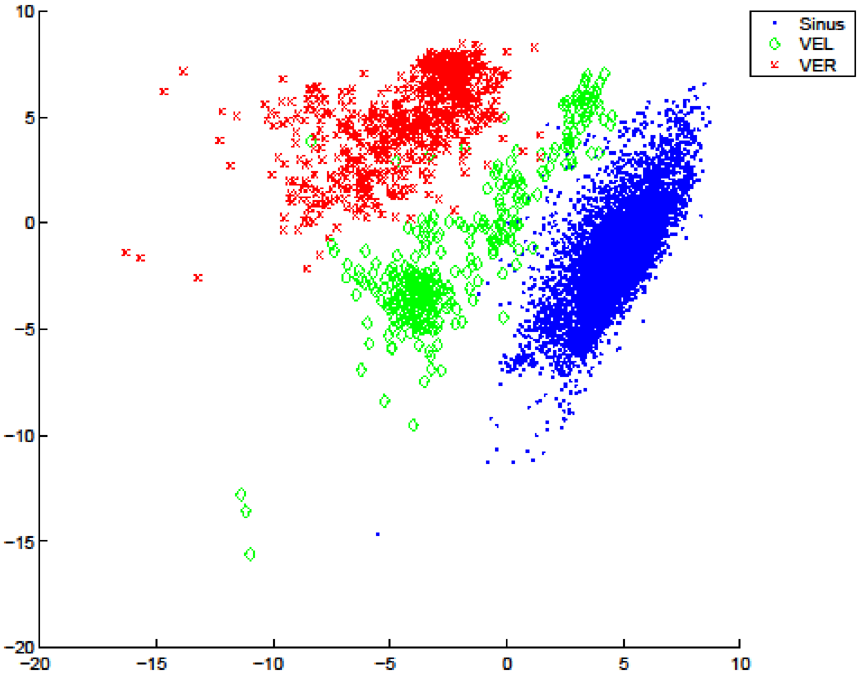
Doubt is not a pleasant condition, but certainty is absurd.

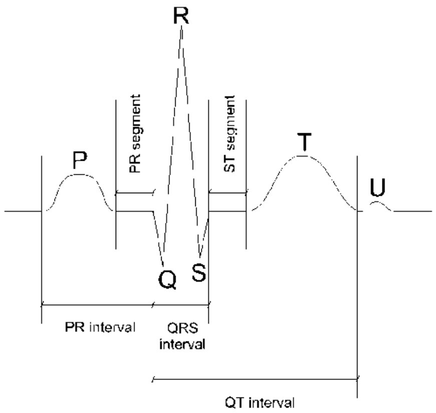
Voltaire

- Real data is noisy.
- We are forced to deal with uncertainty, yet we need to be quantitative.
- The optimal formalism for inference in the presence of uncertainty is probability theory.
- We assume the presence of an underlying regularity to make predictions.
- Bayesian inference allows us to reason probabilistically about the model as well as the data.

ECG Analysis

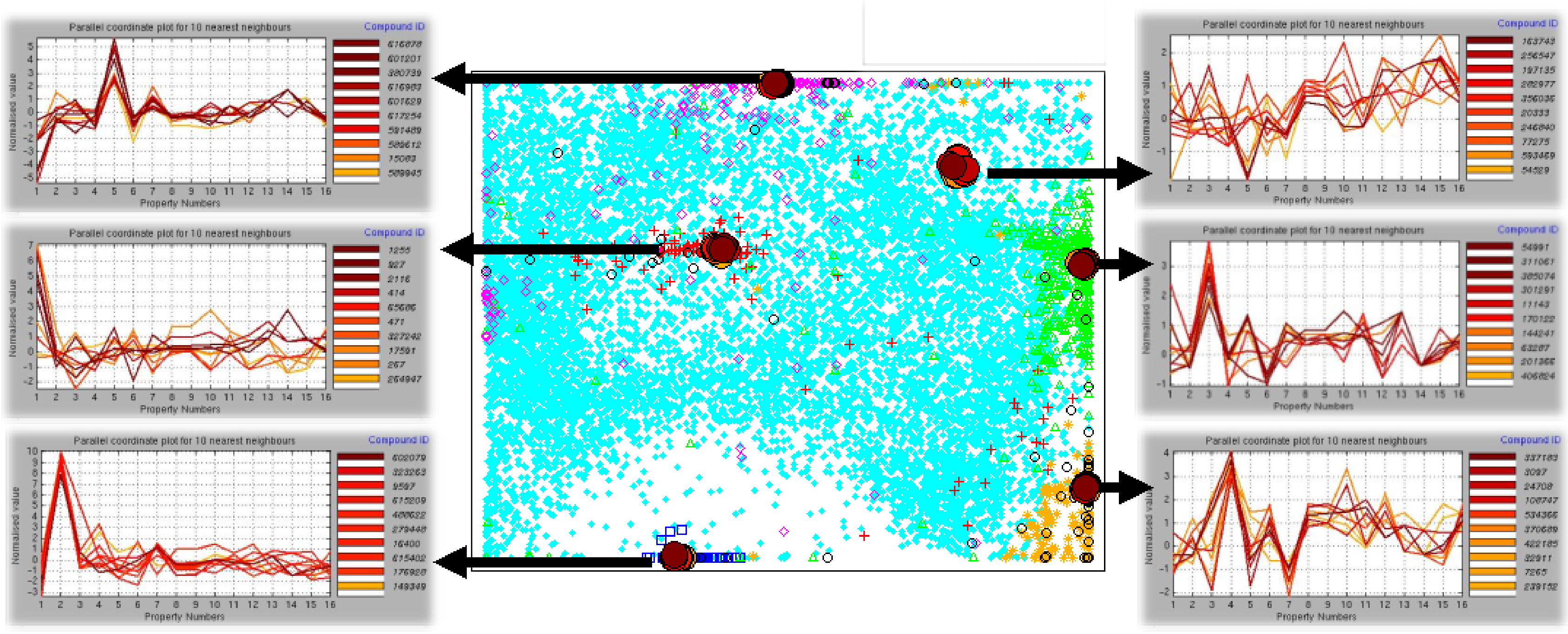






What can we learn from this?

Interactive Visualisation Tool

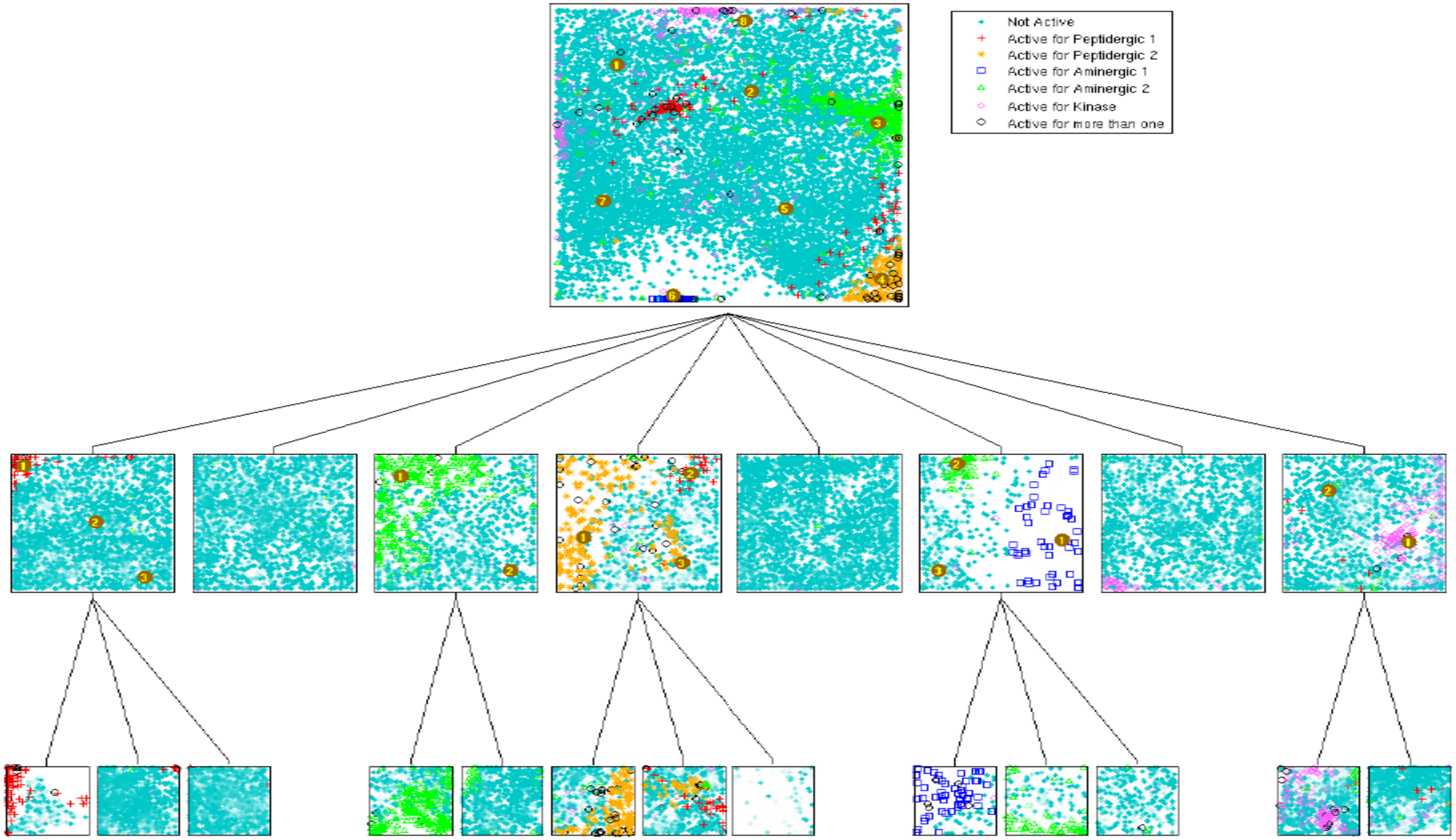


Enhancements to GTM

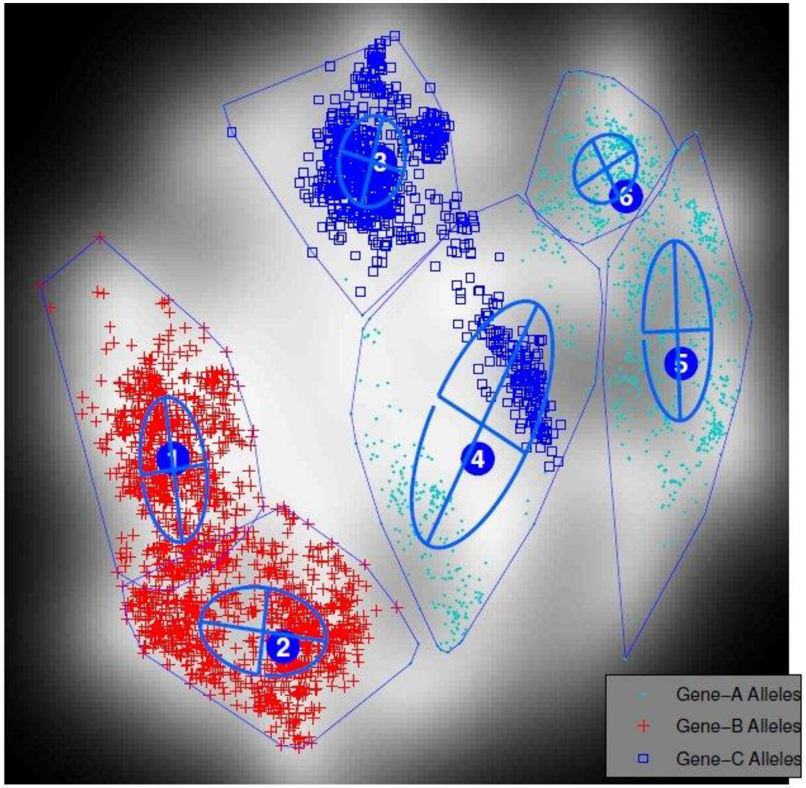
Currently a very active area of research:

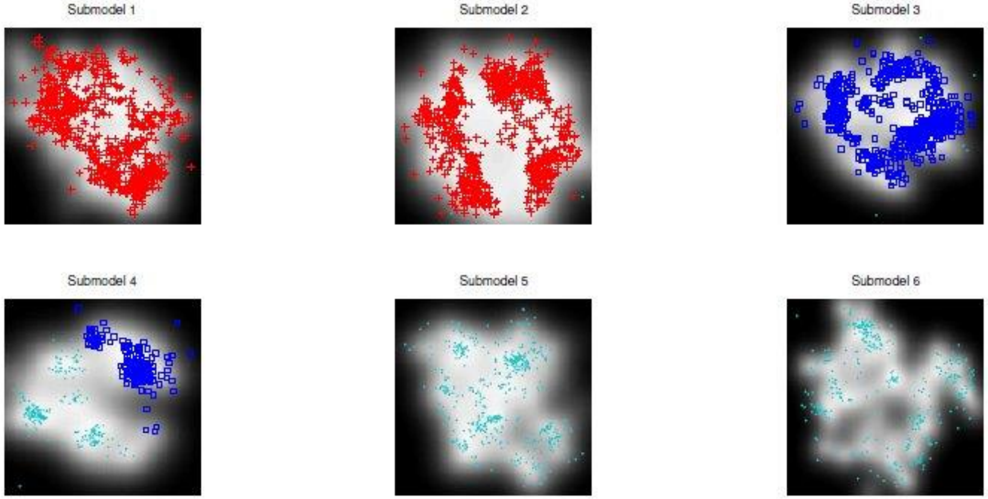
- Curvatures and magnification factors give more information about shape of manifold.
- Hierarchy allows the user to drill down into data; either user-defined or automated (MML) selection of sub-model positions.
- Temporal dependencies in data handled by GTM through Time.
- Discrete data handled by Latent Trait Model (LTM): all the other goodies work for it as well.
- Can cope with missing data in training and visualisation.
- MML methods for feature selection.
- Structured covariance.
- Uncertainty measures

Hierarchical Visualisation



Proteomics

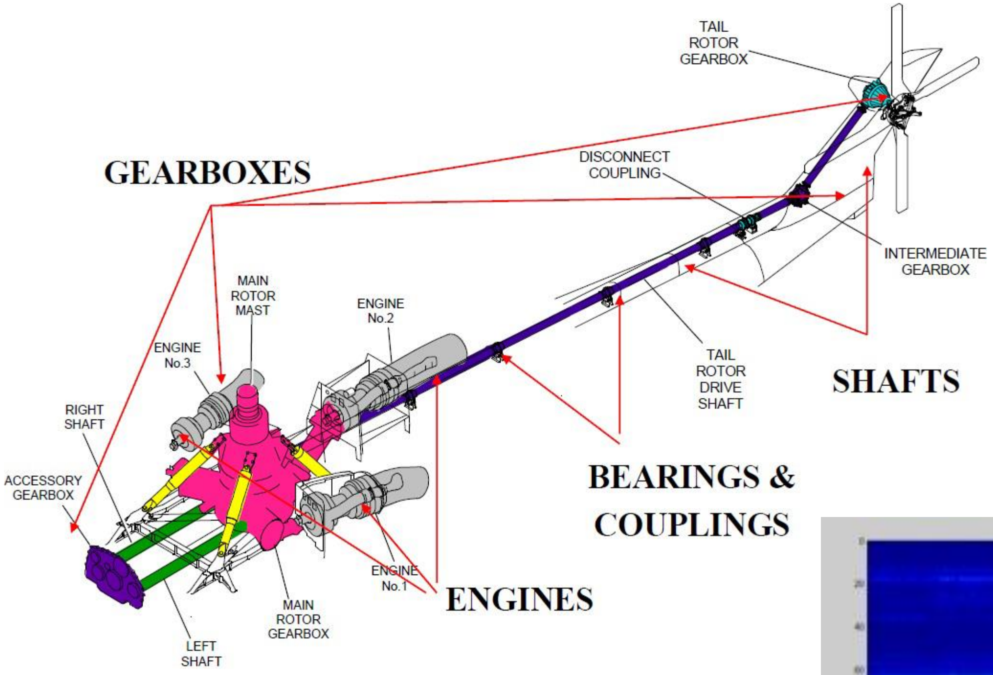

3
6
5
4
1
2
Gene–A Alleles
Gene–B Alleles
Gene–C Alleles


Submodel 1
Submodel 2
Submodel 3
Submodel 4
Submodel 5
Submodel 6

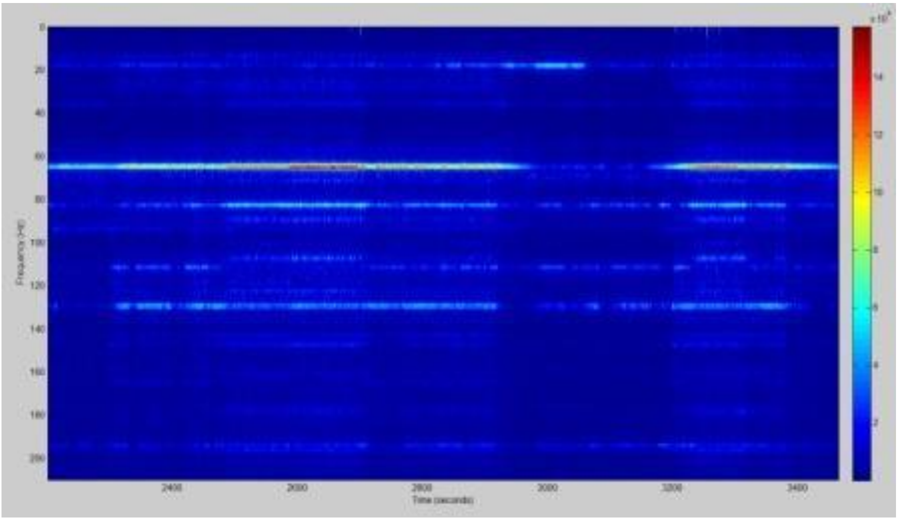
Agusta Westland

- AW has pioneered CVM, the continuous recording of airframe vibration (0-200Hz), to improve the investigation of unusual occurrences and monitor airframe integrity.
- Develop a probabilistic framework for inferring flight mode and key parameters from multiple streams of vibration data.
- Improve indicators of airframe condition: the wavelet transform and kernel entropy to assess the dynamics (i.e. non-stationary characteristics) of the vibration signal.
- Integrated diagnosis based on probabilistic models of normality and using a belief network to model prior knowledge about the domain and interactions between key variables.

Understanding the Data



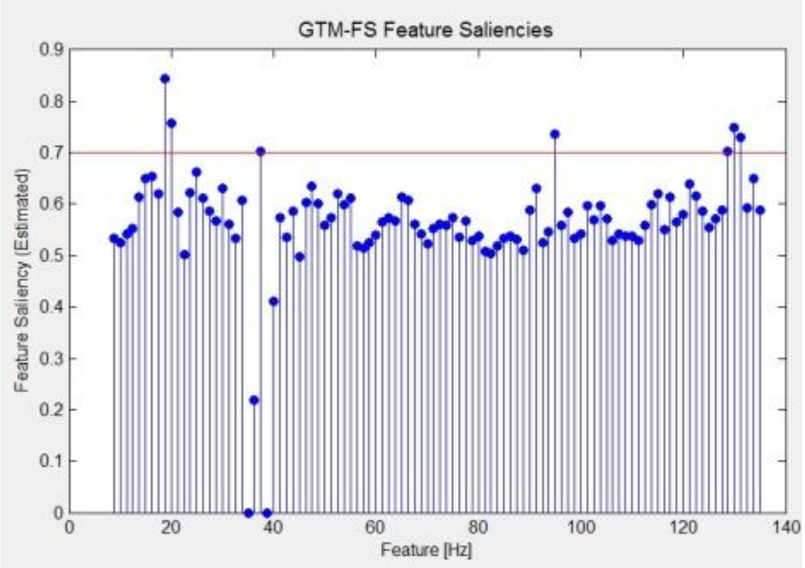
- •8 sensors measuring vibration
- •108 frequency bands (STFFT) for each sensor
- •Too much data to build a model from.

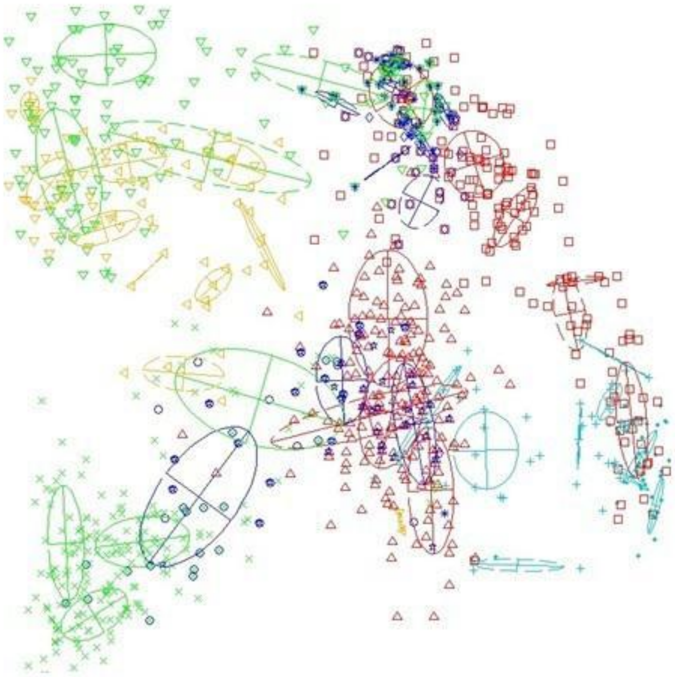


Feature Selection

Features are selected using GTM with Feature Saliencies.

Sensors are selected by comparing inter-class separation in different plots.





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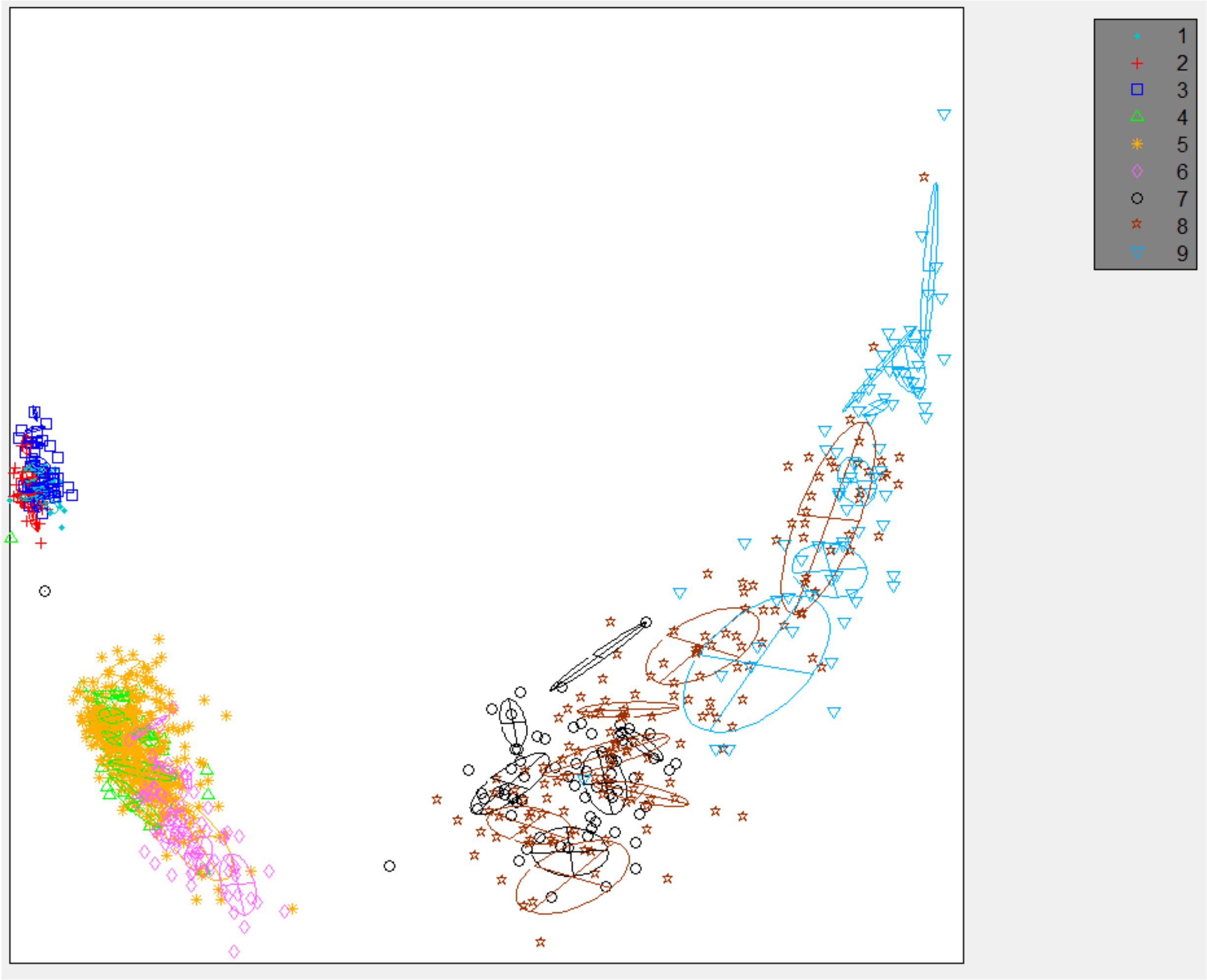
Flying through the visualisation



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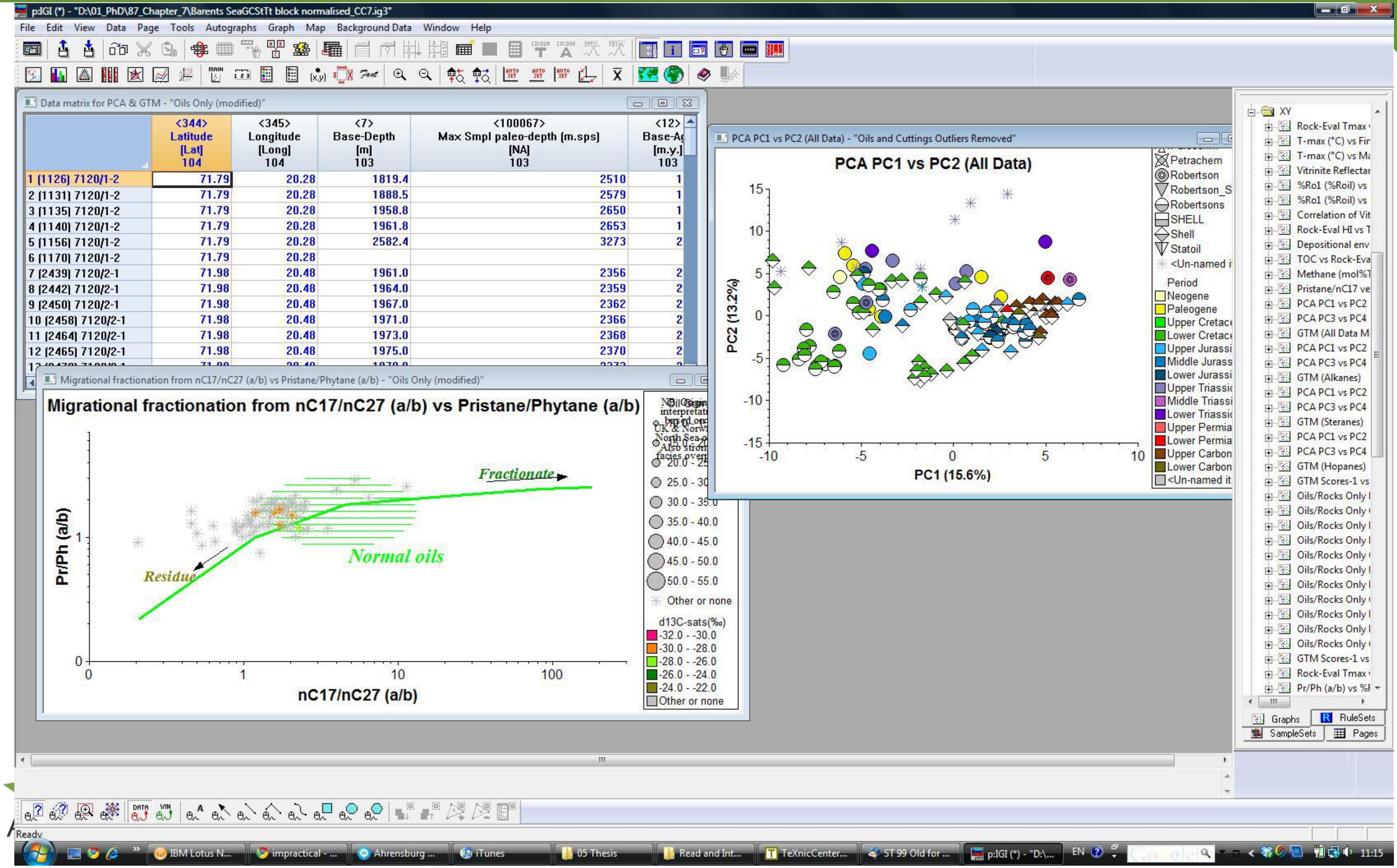
Petroleum geochemistry: pIGI



p:IGI (*) - "D:\01_PhD\87_Chapter_7\Barents SeaGCStTt block normalised_CC7.ig3"

Data matrix for PCA & GTM - "Oils Only (modified)"

	<344> Latitude [Lat] 104	<345> Longitude [Long] 104	<7> Base-Depth [m] 103	<100067> Max Smpl paleo-depth (m.sps) [NA] 103	<12> Base-Ag [m.y.] 103
1 [1126] 7120/1-2	71.79	20.28	1819.4	2510	1
2 [1131] 7120/1-2	71.79	20.28	1888.5	2579	1
3 [1135] 7120/1-2	71.79	20.28	1958.8	2650	1
4 [1140] 7120/1-2	71.79	20.28	1961.8	2653	1
5 [1156] 7120/1-2	71.79	20.28	2582.4	3273	2
6 [1170] 7120/1-2	71.79	20.28			
7 [2439] 7120/2-1	71.98	20.48	1961.0	2356	2
8 [2442] 7120/2-1	71.98	20.48	1964.0	2359	2
9 [2450] 7120/2-1	71.98	20.48	1967.0	2362	2
10 [2458] 7120/2-1	71.98	20.48	1971.0	2366	2
11 [2464] 7120/2-1	71.98	20.48	1973.0	2368	2
12 [2465] 7120/2-1	71.98	20.48	1975.0	2370	2

PCA PC1 vs PC2 (All Data) - "Oils and Cuttings Outliers Removed"

Migrational fractionation from nC17/nC27 (a/b) vs Pristane/Phytane (a/b) - "Oils Only (modified)"

Ready

Big Data Issues

- Almost all interesting questions involve multivariate answers.
- Don’t forget the lessons of Medium Data:
    - data integrity;
    - non-linearity;
    - generalisation (training vs test: speed, reliability);
    - feature selection;
    - diagnostics.
- Scaling in number of variables and number of examples
    - Hierarchies: divide and conquer
    - Move as little information as possible
    - Models as ‘data summarisers’
    - Bayes (again!) to combine data, information, models, …

Institute of Omnivariate Data Analytics

- Full ‘data to decision’ process: high-dimensional visualisation, information extraction, uncertainty modelling, inference techniques, data fusion, knowledge management, data curation, and web technologies
- 19 UK partners (mainly companies) and 4 international partners
- Bidding for a Centre for Doctoral Training
  - Research training
  - Partnerships: pilot projects; short courses and workshops; international exchanges; entrepreneurship
  - Open-source software

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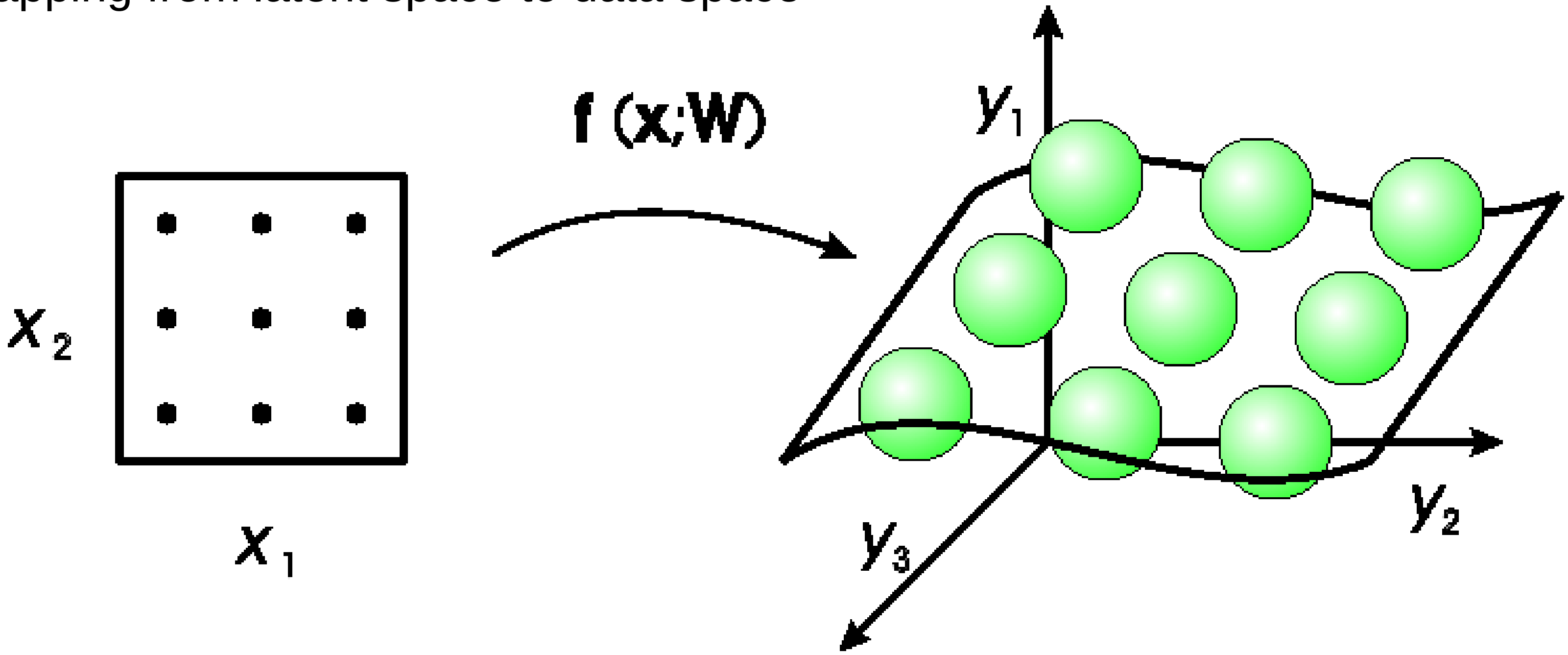
Conclusions

- We need to understand the vast quantities of data that surround us; visualisation and machine learning can help us in that task.
- Models can be used to uncover the hidden meanings of data.
- Visual analytics is a powerful tool that provides insight to non-specialists.
- A probabilistic approach provides many benefits.
- It is a multivariate, multi-skilled, collaborative effort.

Generative Topographic Mapping

Mapping from latent space to data space



A thick rubber sheet studded with tennis balls. GTM defines p(y|x;W); use Bayes' theorem to compute p(x|y*;W) for a given point y* in data space.