Multiscale modeling
Analysis tools
Fly wing model
Fly wing model

- Concentration of a particular protein complex (FFD) influence hair growth
- Discriminate the cells by FFD concentration behaviour in both proximal (left) and distant (right) compartments
Clustering

- Clustering is the process of grouping a set of objects in groups called clusters.
- Objects belonging to the same cluster have high similarity.
- Objects belonging to different clusters have low similarity.
Time Series Clustering

- The curve can be represented as a vector $v \ in \ \mathbb{R}^n$ of time points.
- $N$ (the number of time points) is usually very large.
- We apply Principal Component Analysis to reduce the space (by looking at the most important time points).
- $\mathbb{R}^n \rightarrow \mathbb{R}^m$ (where $m << n$).
Clustering

• Classic clustering techniques can usually recognize spherical shapes

• But the clusters can be difficult to recognize:
  • Different shapes
  • Different sizes
Density-Based Clustering

- Detects “dense areas” of space
- Can detect clusters of arbitrary shape
- Needs two parameters to define density:
  - $Eps$: radius of the neighborhood
  - $MinPts$: min number of points to form a cluster
Density-Based Clustering

Original Points

Clusters
Mutated Tissue Result
Mutated Tissue Result
From time series to temporal logic

- Temporal logics are formal languages used to describe time series

- PLTLc: Probabilistic Linear Time Logic with constraints

- We can describe the behaviour of a curve (both wet lab or simulation trace)

- Ex. \( P=\? [ d(\text{Protein}) > 0 \ U \ ( G( d(\text{Protein}) < 0 ) ) ] \)
  “The concentration of Protein rises then falls”
Automatically Generated Descriptions

- How can we characterize a cluster of time series with PLTLc?

  - The PLTLc description must be general enough to include all the curves belonging to the same cluster

  - The description must be specific enough to differentiate time series belonging to different clusters

  - We are looking for the least general description which discriminates between different clusters
Automatically Generated Descriptions

- 3 steps characterization:
  - Derivative trend - different behaviour or time shifts
  - Extrema (min and max points) - different peaks
  - Steady state - different activation level
Automatically Generated Descriptions

\[ P = \{ d[FFD] > 0.01 \cup (d[FFD] > -0.01 \land d[FFD] < 0.01) \cup (d[FFD] < -0.01) \} \]

\[ P = \{ d[FFD] > 0.01 \cup (d[FFD] > -0.01 \land d[FFD] < 0.01) \} \]
P = \left[ F(FFD) \geq 0.59355 \land FFD \leq 0.63943 \land \text{Time} \geq 4 \land \text{Time} \leq 7 \right] \land d[FFD] > 0.01 \lor (d[FFD] > -0.01 \land d[FFD] < 0.01)
P = \{ d[FFD] > 0.01 \lor (d[FFD] > -0.01 \land d[FFD] < 0.01) \land G([FFD] \geq 0.94 \land [FFD] \leq 1) \}