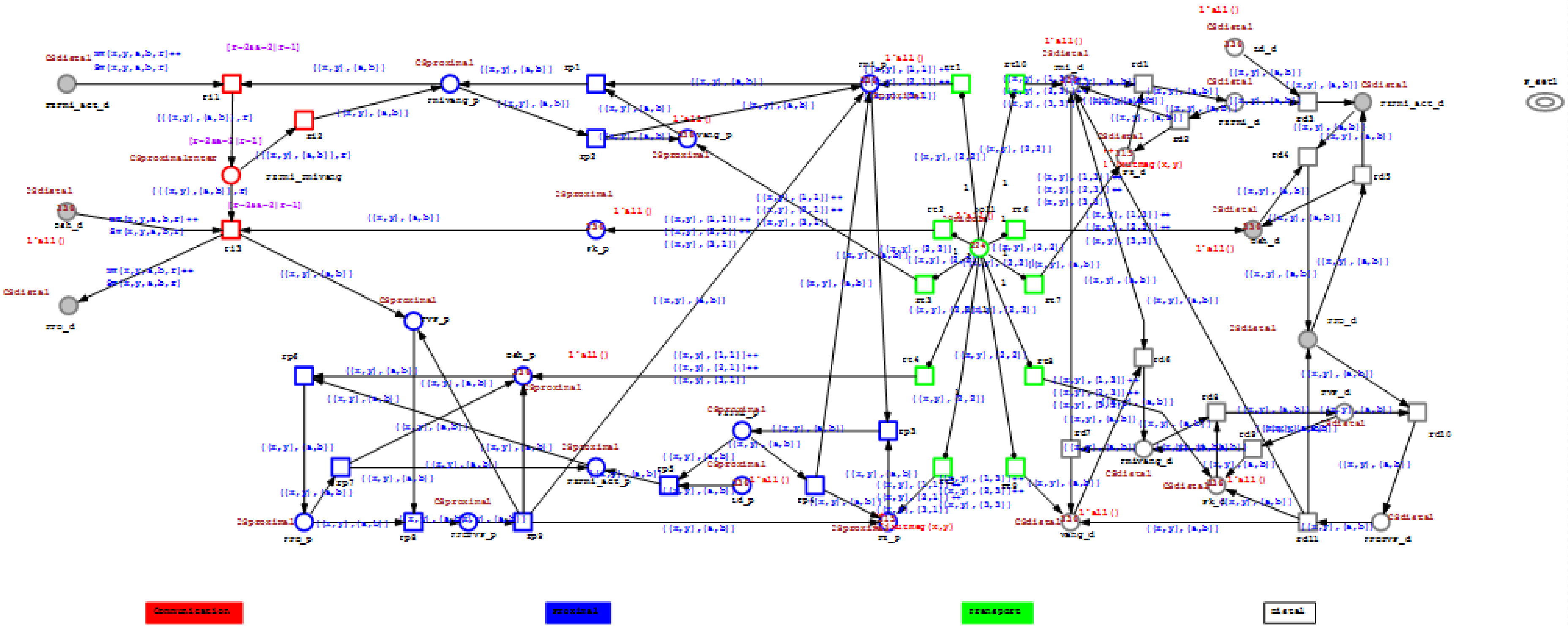
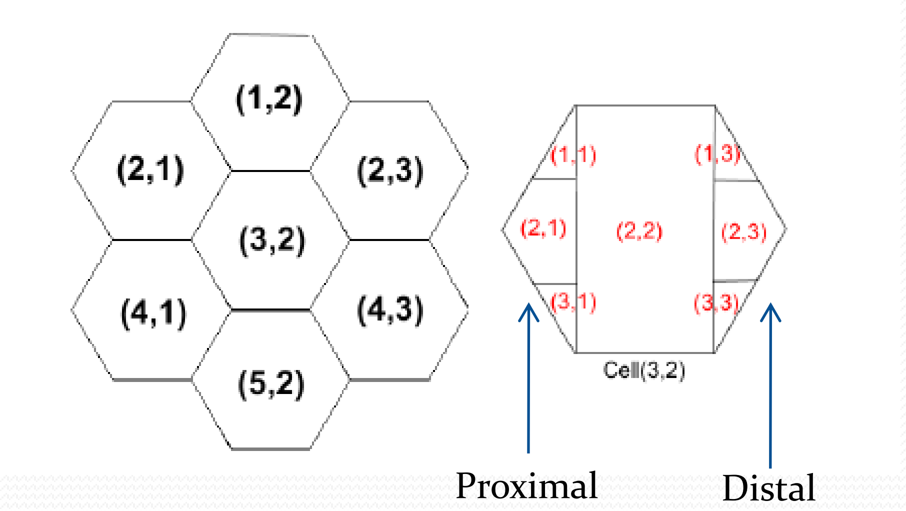
Multiscale modeling
Analysis tools

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) comparments



Clustering

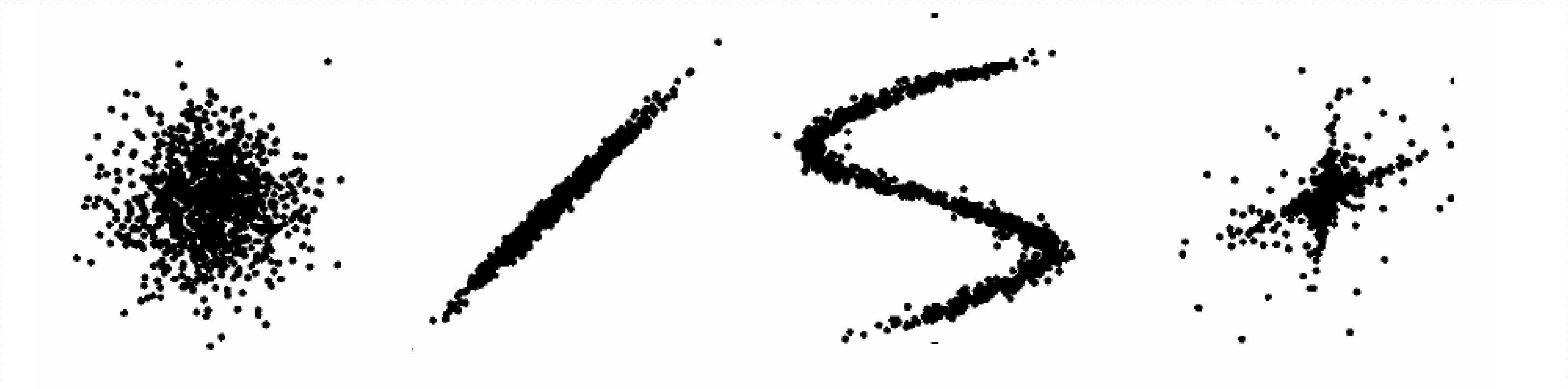
- Clustering is the process of grouping a set of objects in groups called *clusters*
- Object belonging to the same cluster have high similarity
- Objects belonging to different clusters have low similarity

Time Series Clustering

- The curve can be represented as a vector v app a 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)
- R^n -> R^m (where m << n)

Clustering

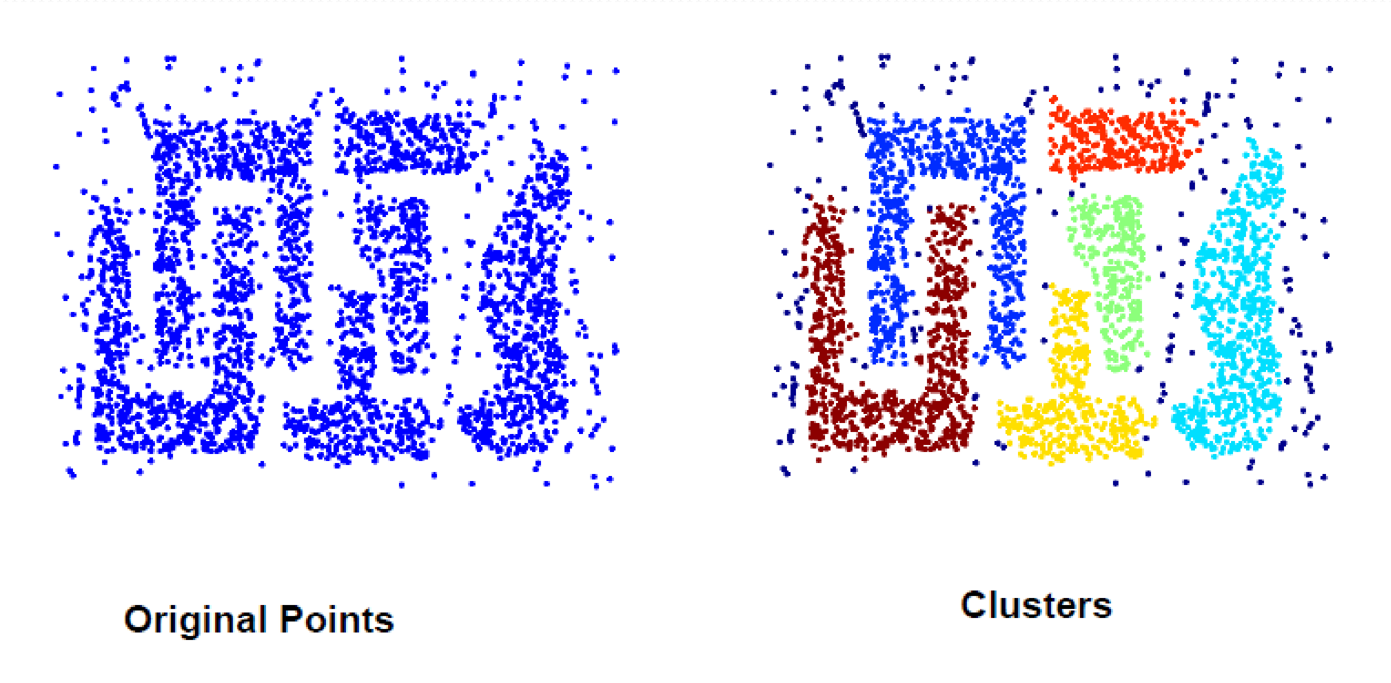
- Classic clustering techniques can usually recognize spherical shapes
- But the clusters can be difficult to recognize:
  - Different shapes
  - Different sizes



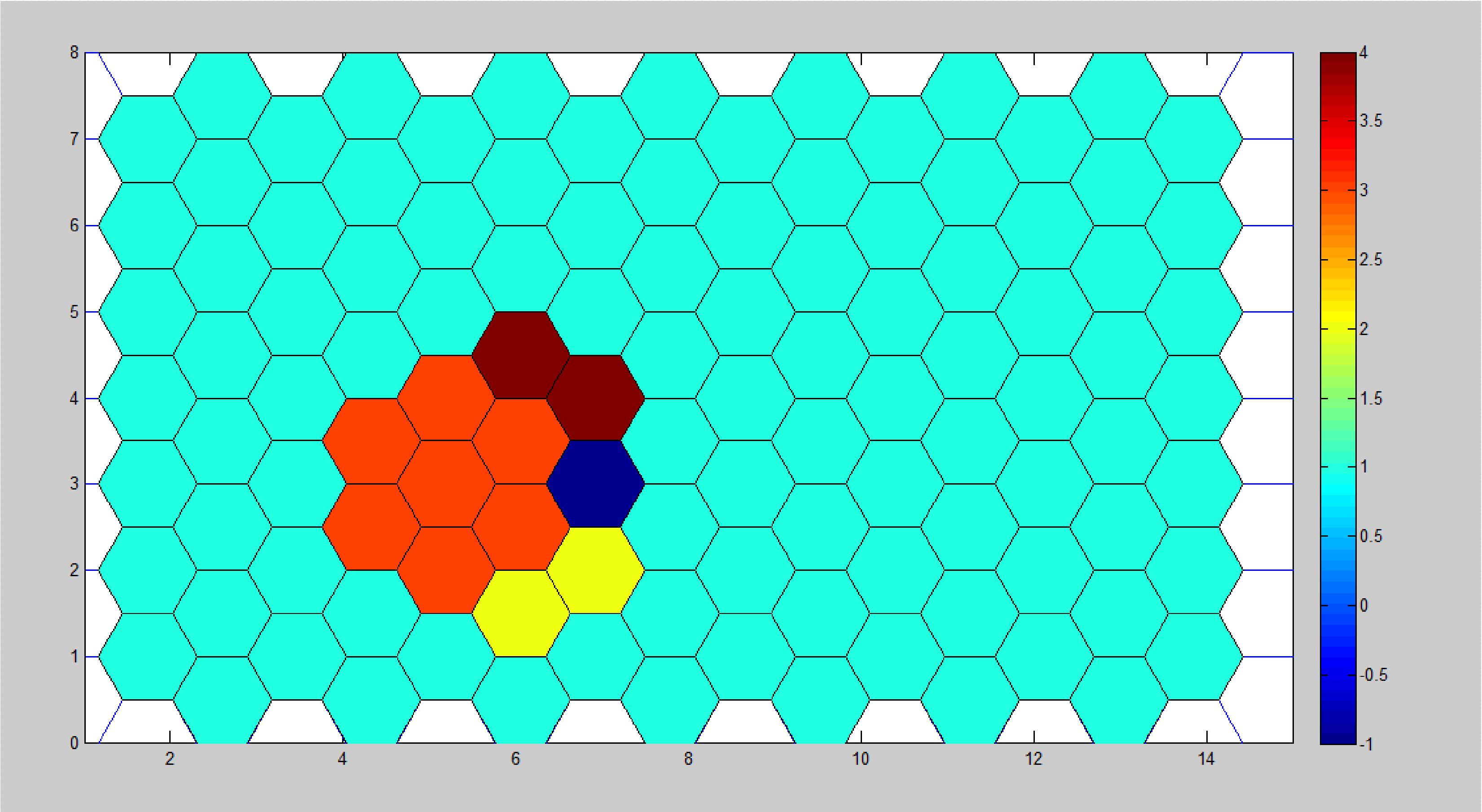
Density-Based Clustering

- 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

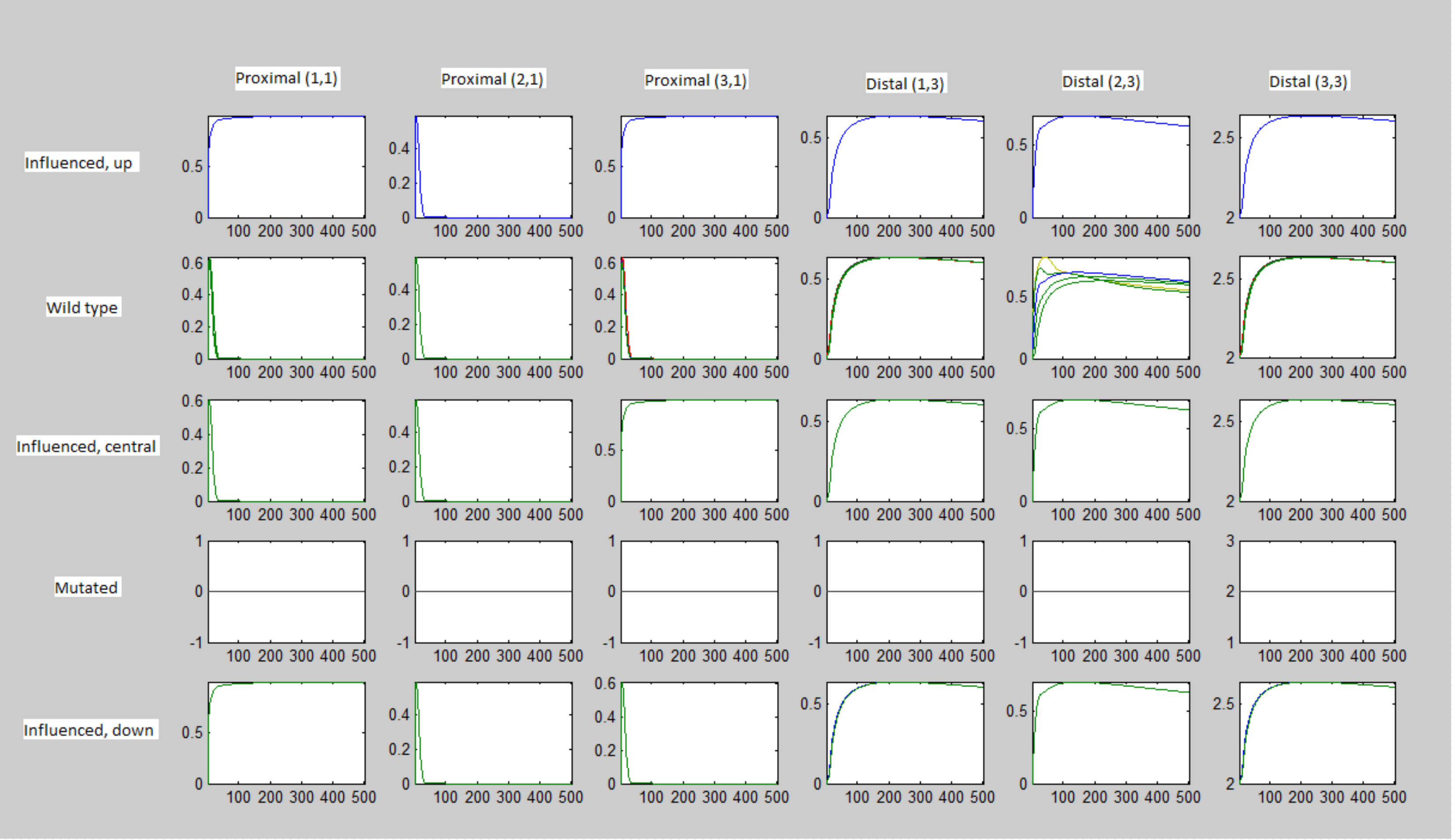
Density-Based Clustering



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(Protein) > 0 U (G(d(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

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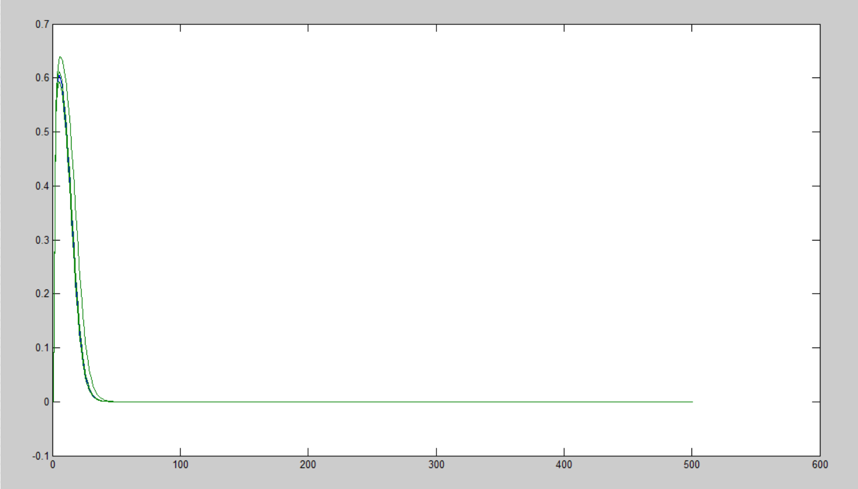
  - We are looking for the least general description which discriminates between different clusters

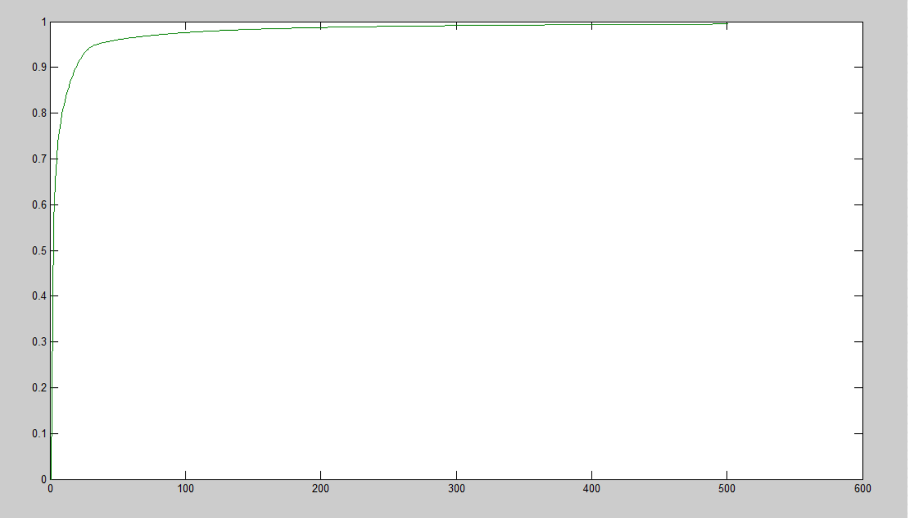
Automatically Generated Descriptions

- 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

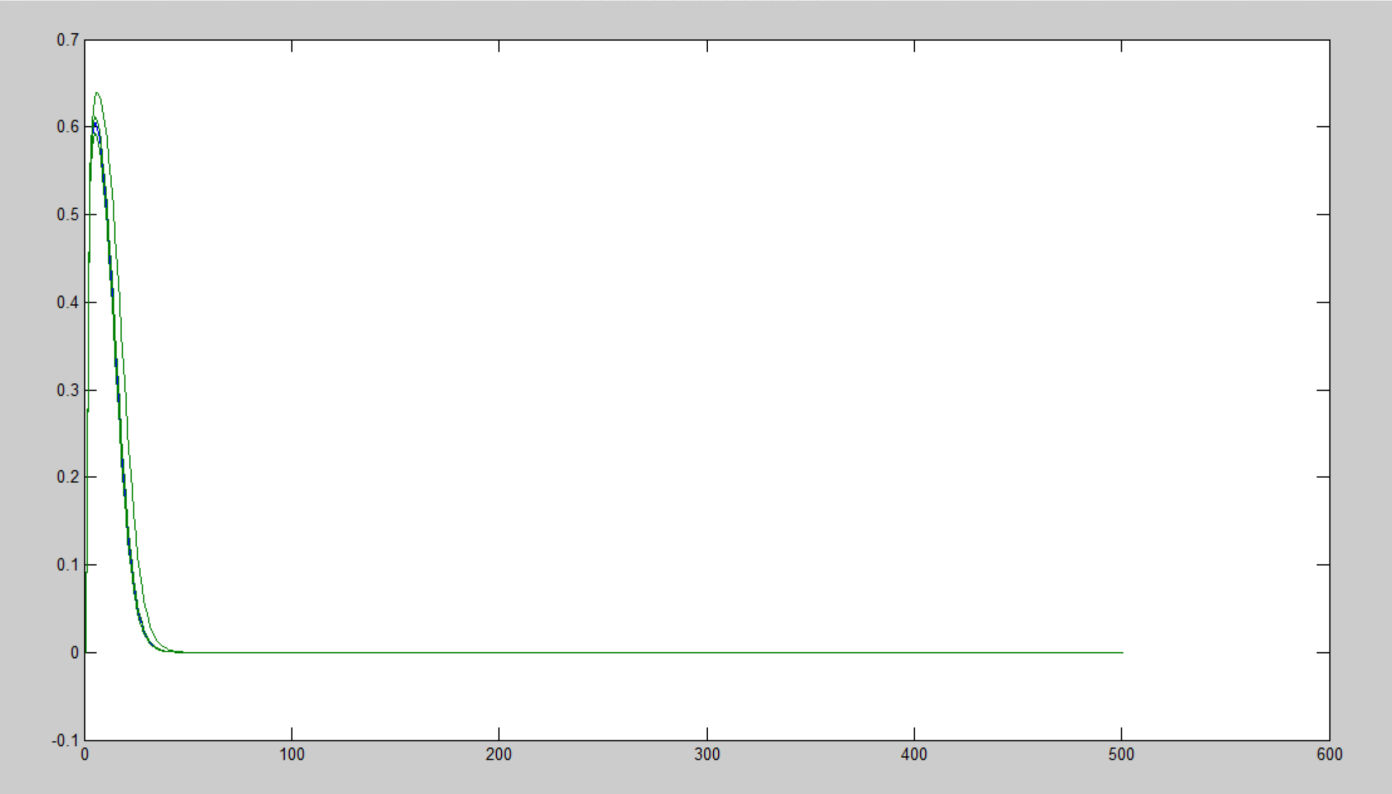
P=? [d[FFD]> 0.01 U (d[FFD]> -0.01 ^ d[FFD]< 0.01 U (d[FFD]< -0.01 U (d[FFD]> -0.01 ^ d[FFD]< 0.01)))]





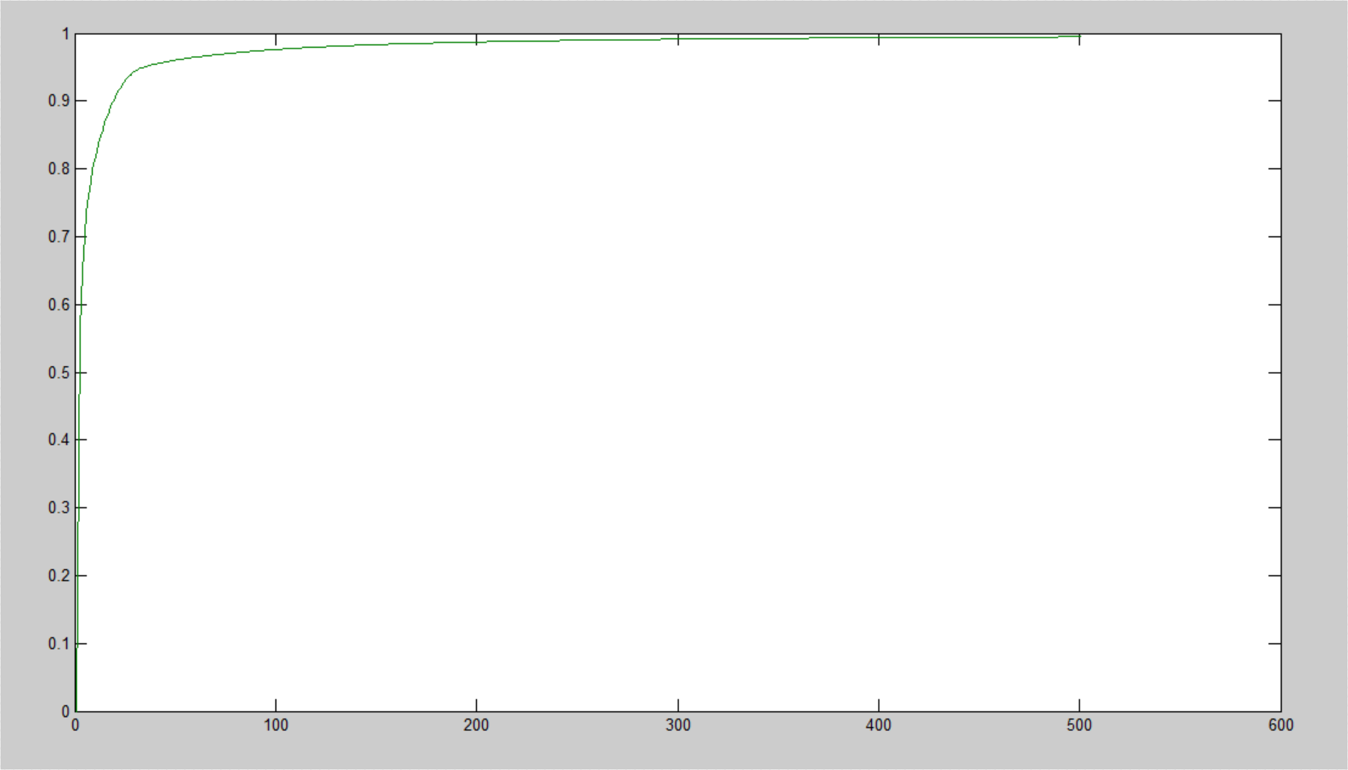
P=? [d[FFD]> 0.01 U (d[FFD]> -0.01 ^ d[FFD]< 0.01)]

Automatically Generated Descriptions



P=? [F([FFD] >= 0.59355^ [FFD] <= 0.63943 ^ Time >= 4 ^ Time <= 7) ^ d[FFD]> 0.01 U (d[FFD]> -0.01 ^ d[FFD]< 0.01 U (d[FFD]< -0.01 U (d[FFD]> -0.01 ^ d[FFD]< 0.01)))]

Automatically Generated Descriptions



P=? [d[FFD]> 0.01 U (d[FFD]> -0.01 ^ d[FFD]< 0.01 ^ G([FFD] >= 0.94 ^ [FFD] <= 1))]