Using Unsupervised Learning with ICA to Identify Patterns of Glaucomatous Visual Field Defects

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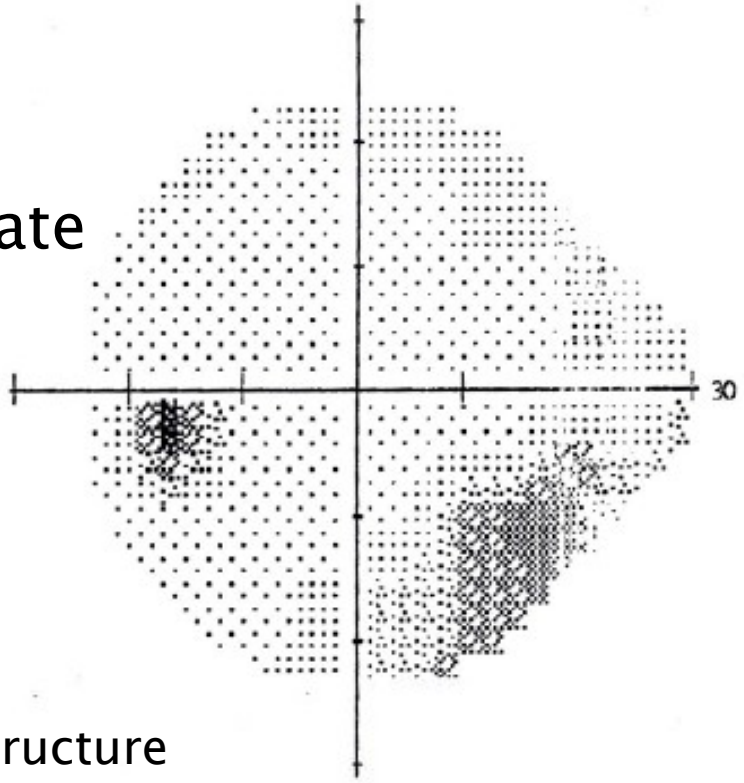
Visual field test

- Prime indicator for functional defects due to glaucoma
  - Detection of progression
  - Diagnosis
- Visual field defect **patterns** indicate glaucoma
  - Expert knowlegde
  - Grown over “generations”
- Application of machine learning
  - Classification by supervised learning
  - Clustering by **un**supervised learning
    - Organize input data to meaningful structure

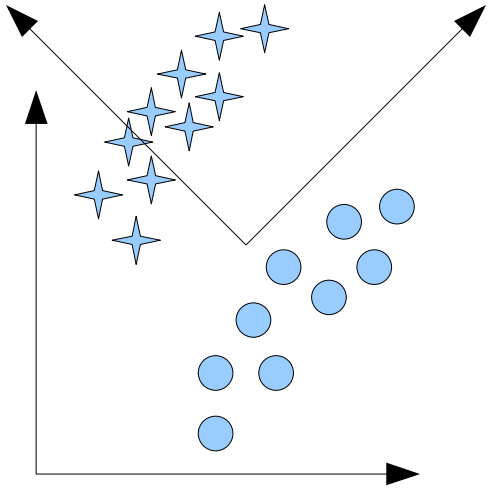


Assumption -> Goal of the study

Unsupervised learning techniques
can explore
relevant and meaningful, but hidden patterns
from
(visual field defect) data !

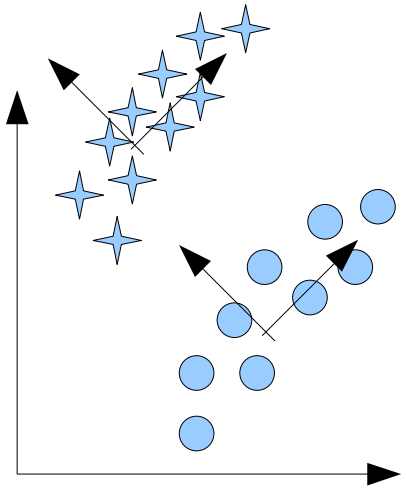
Variational Bayesian ICA mixture model

- Component Analysis:
  - Project data onto axes that meaningful represent the data
- Principal Component Analysis:
  - Projection maximizes data variance
  - Dimension reduction
- Independent Component Analysis:
  - Produce axes the are maximally independent
  - Components are statistically independent
- One single model may represent data suboptimal



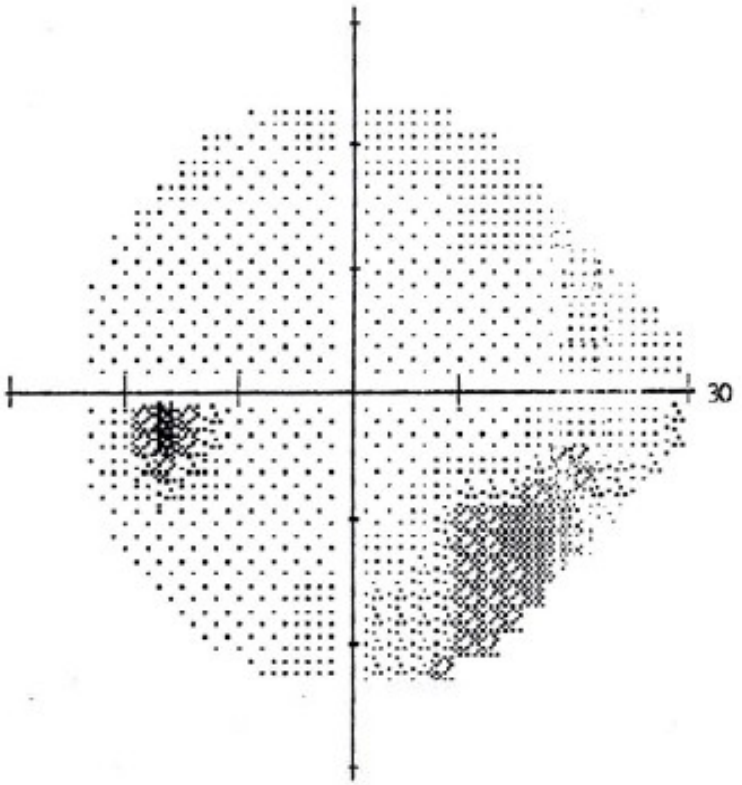
Variational Bayesian ICA mixture model

- ICA mixture model
  - Non linear ICA technique
  - Learning multiple ICA models for each cluster
  - Weight each instance probabilistically
  - Optimizes
    - Axes
    - Number of clusters
  - Optimization via variational Bayesian approx. techniques



Data

- Visual field test
- 345 eyes
  - 156 GON
  - 189 normal
- Feature vector
  - 52 visual field locations
  - Age

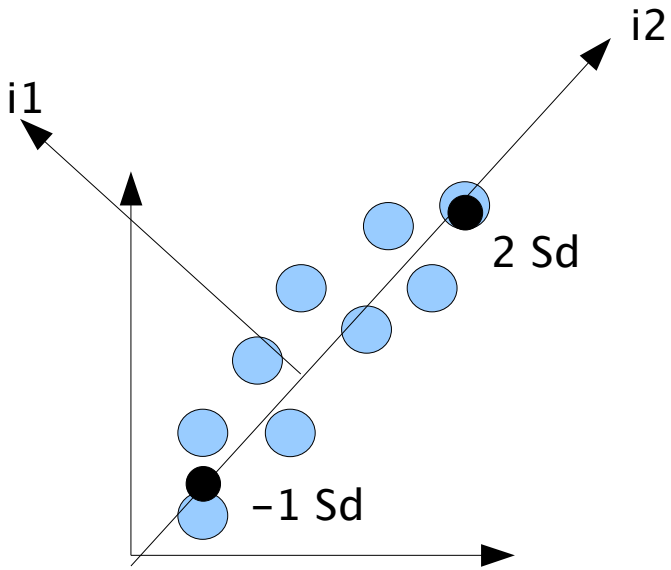


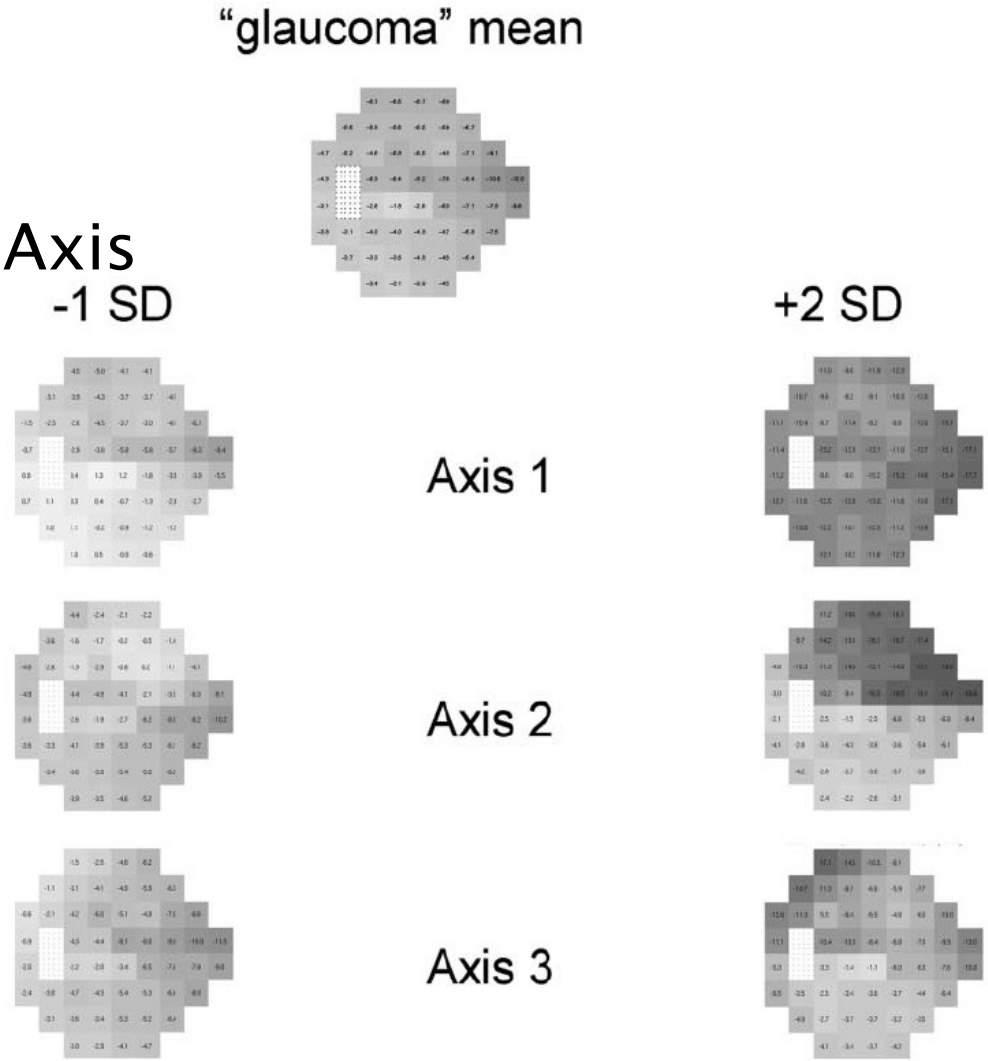
Result: Clusters

- Two separate clusters found
- Cluster “Glaucoma”:
  - 107 glaucomatous, 3 normal
- Cluster “Normal”:
  - 186 normal, 49 glaucomatous
  - Represented by only one axis
- Discussion:
  - Cluster structure correlate well with structure obtained by supervised technique

Cluster: “Glaucoma”

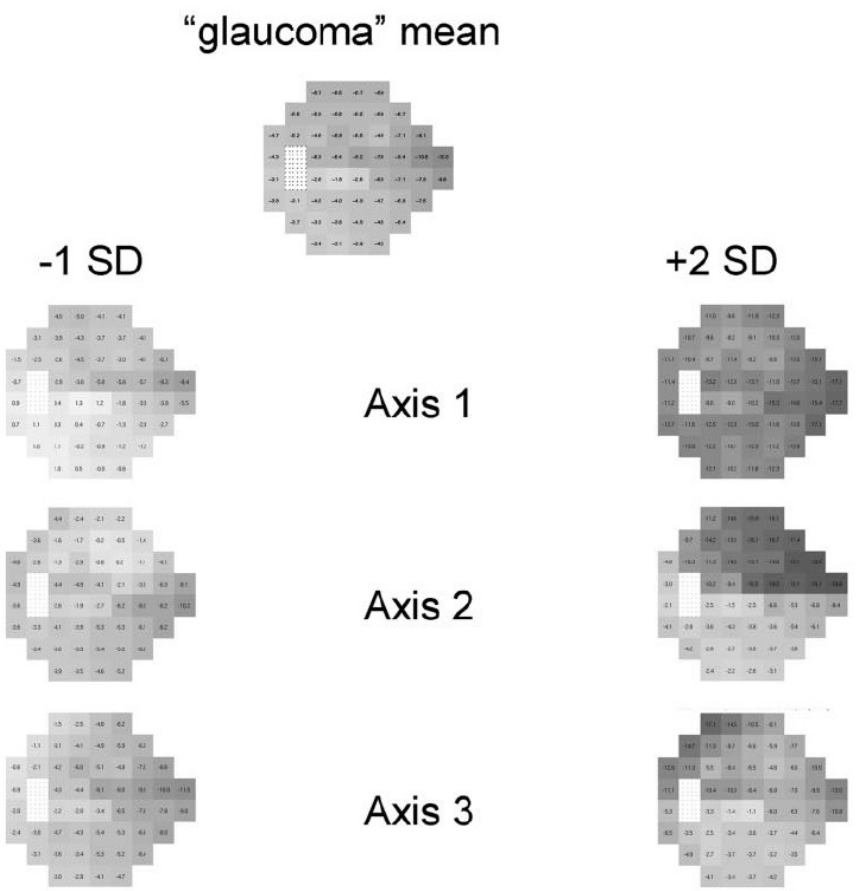
- 6 axes (i) were selected
  - criteria: reconstruction error
- Pattern Shift Along each Axis





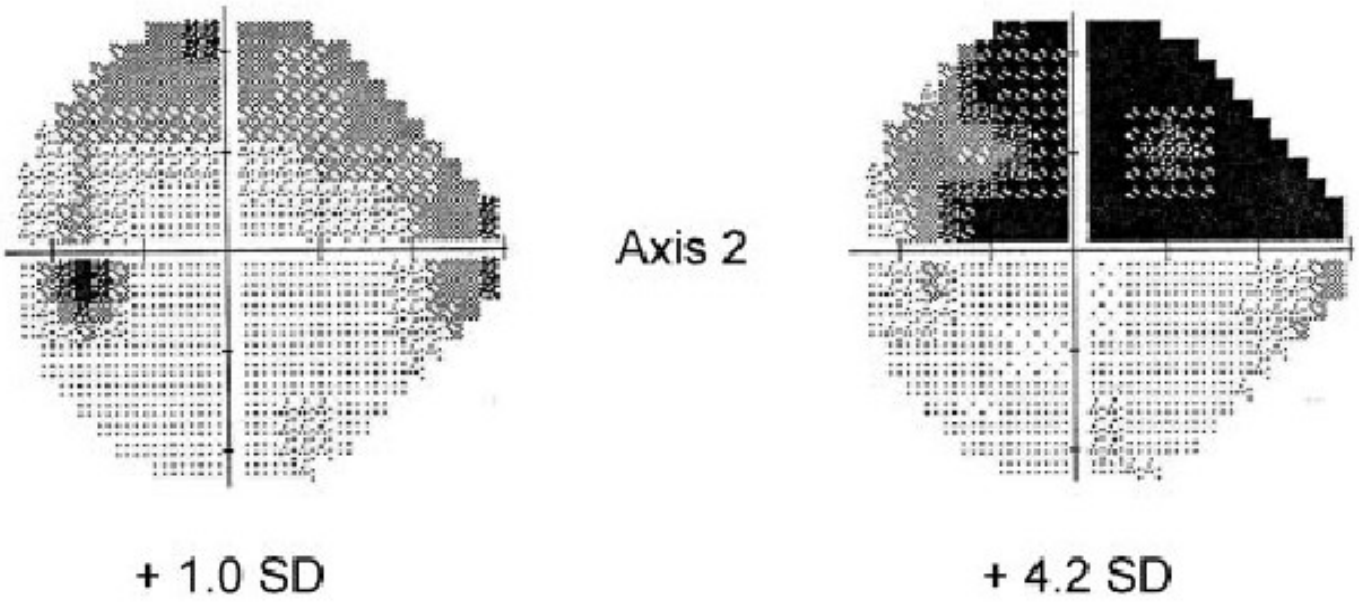
Cluster: “Glaucoma”

- Generated patterns represented by axis differ from each other
- Patterns resemble classic glaucoma patterns
  - Represent medical knowledge over generations
- Patterns on one axis can be considered as complementary



Cluster: “Glaucoma”

- Axis capture degree of severity



Summary and conclusion

- Unsupervised cluster and component analysis
- Extraction of meaningful
  - Clusters
  - Patterns
- ICA axes capture the sense of severity

- Conclusion:
  - (Un)supervised learning has the potential of grouping patterns that are more useful than achieved by statistical methods.
  - Unsupervised techniques might extract information still hidden to humans.
    - e.g. DTI? GRI ?