IC SEM RE Tutorial using AI
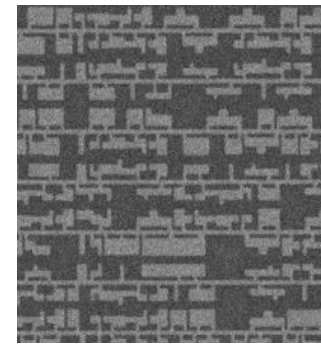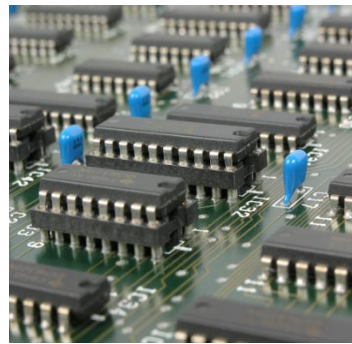# Part 3: Unsupervised Machine Learning

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Objective

- Hardware Reverse Engineering Project using AI
  - Hands-on tutorial
  - Practical application in hardware assurance
  - Resume-builder / professional development
- Last Time:
  - Introduced Image Processing and Computer Vision
  - Improve upon previous code pipeline
- This lecture:
  - Introduce Unsupervised Machine Learning
 - Improve upon previous code pipeline

Refer to the prerequisites and documentation!

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Machine Learning

- <u>Machine Learning (ML)</u> AI that learns patterns from data
  - Unsupervised
  - Supervised
  - Others (e.g. reinforcement, semi-supervised, etc.)

- TL;DR:
  - Unsupervised: learns <u>without</u> ground truth
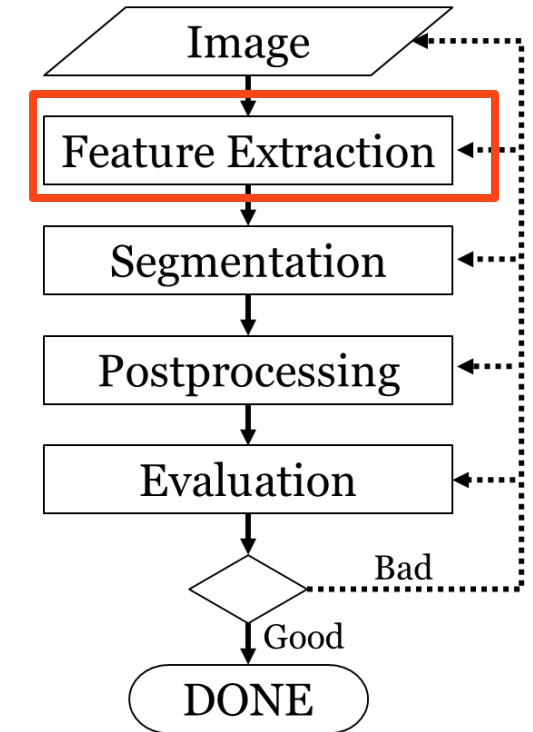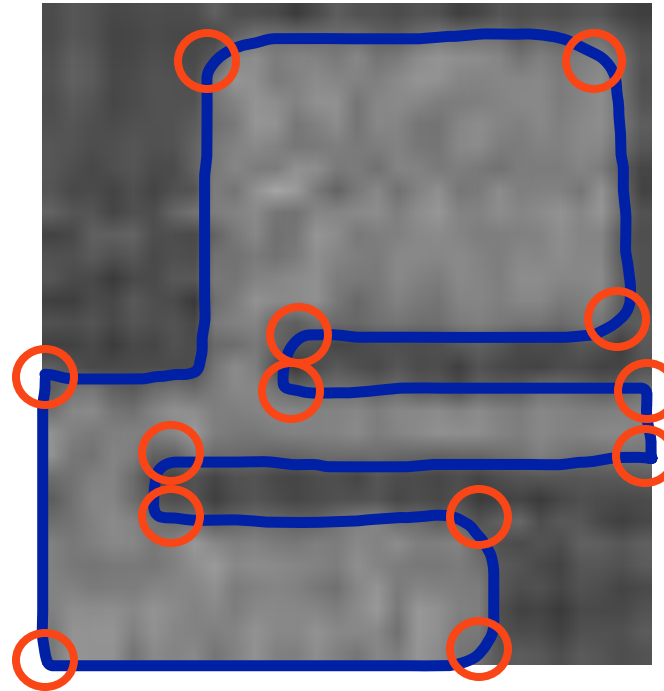 - Supervised: learns <u>from</u> ground truth
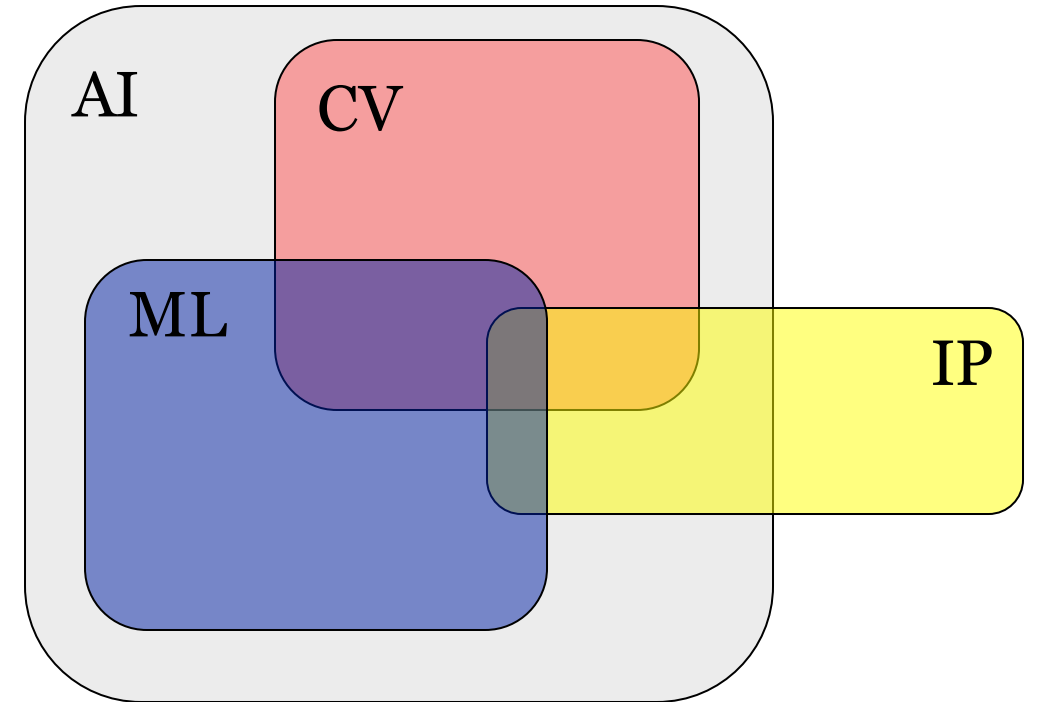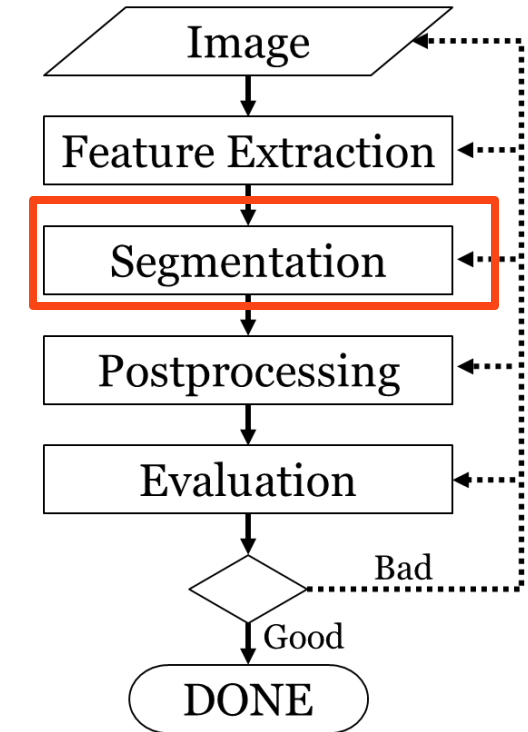
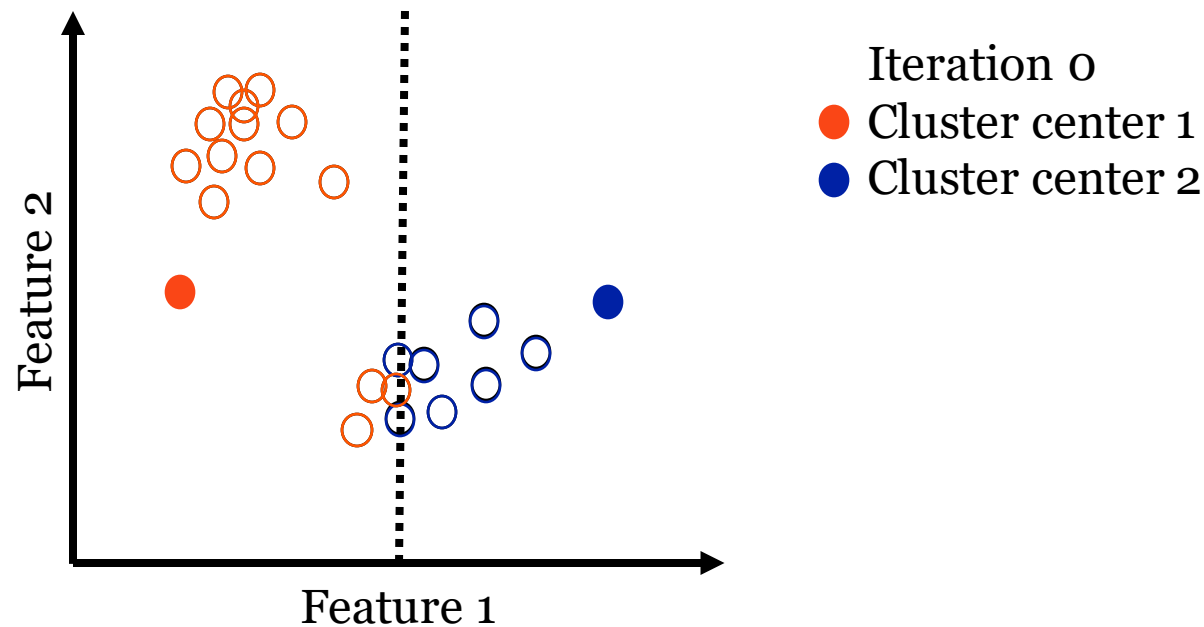# Typical ML Segmentation Pipeline
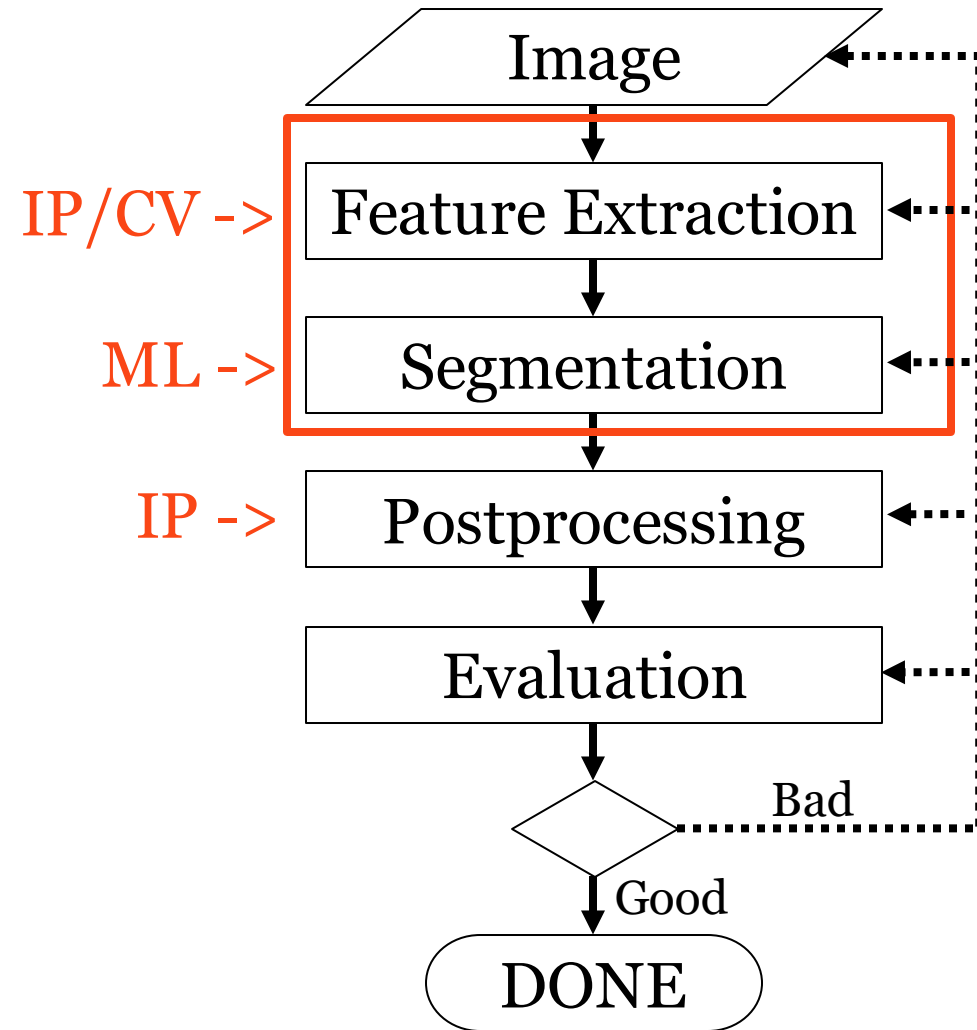
Feature Extraction

- Techniques to obtain information from input

- Example features:
  - Intensity
  - Edges
  - Corners
  - Others (e.g. blobs, circles, etc.)

Segmentation Method 3: k-Means Clustering

- Unsupervised ML technique
- Iteratively groups data based on inter-cluster variance
- Needs: number of clusters, input features

Iteration 0
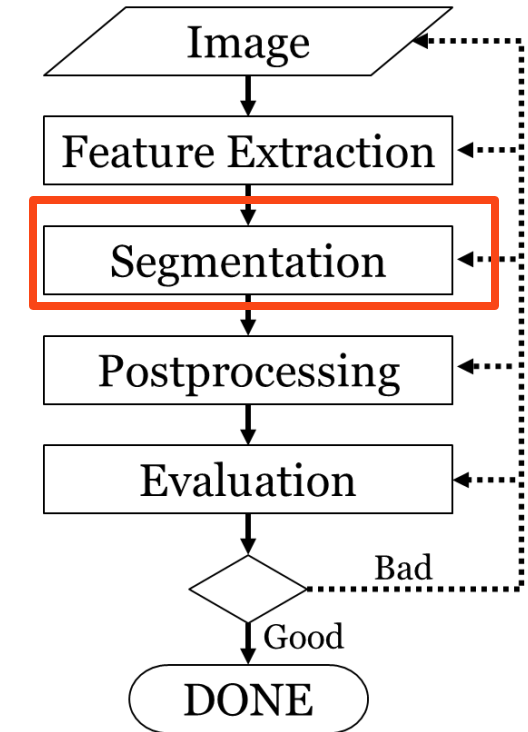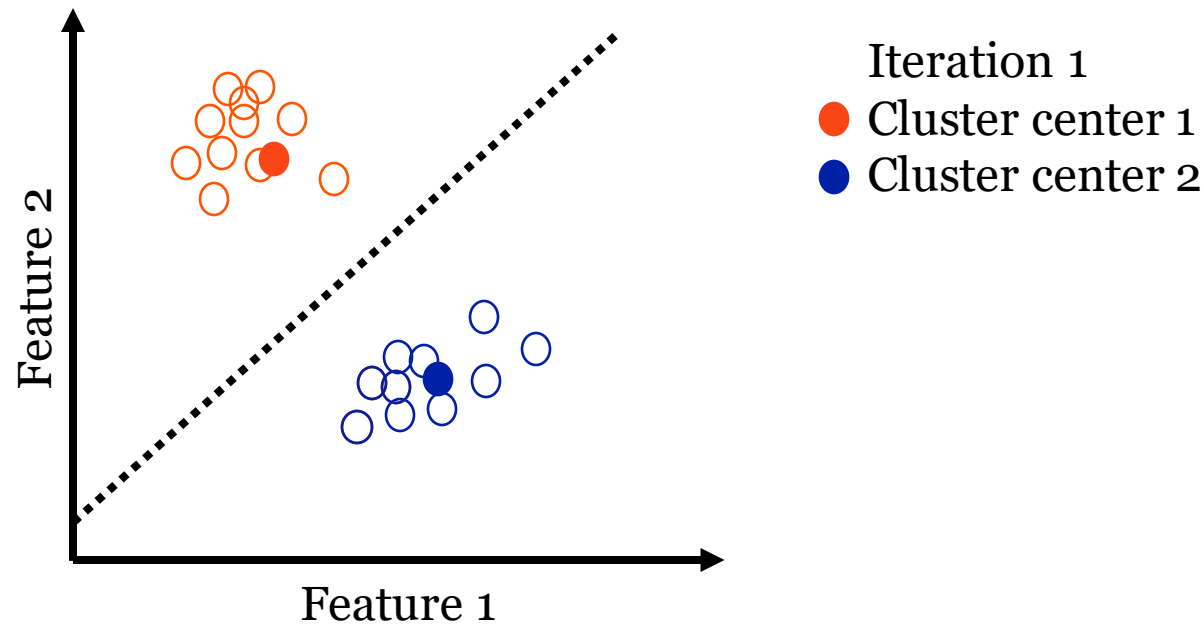- Cluster center 1
- Cluster center 2

Segmentation Method 3: k-Means Clustering

- Unsupervised ML technique
- Iteratively groups data based on inter-cluster variance
- Needs: number of clusters, input features

Iteration 1
- Cluster center 1
- Cluster center 2

Feature 2

Feature 1

Image
Feature Extraction
Segmentation
Postprocessing
Evaluation
Bad
Good
DONE

Model Interpretation: k-Means Clustering

- Explainable AI (XAI) helps humans understand AI algorithms

- k-means clustering: view cluster centers

Iteration 1
🔴 Cluster center 1
🔵 Cluster center 2
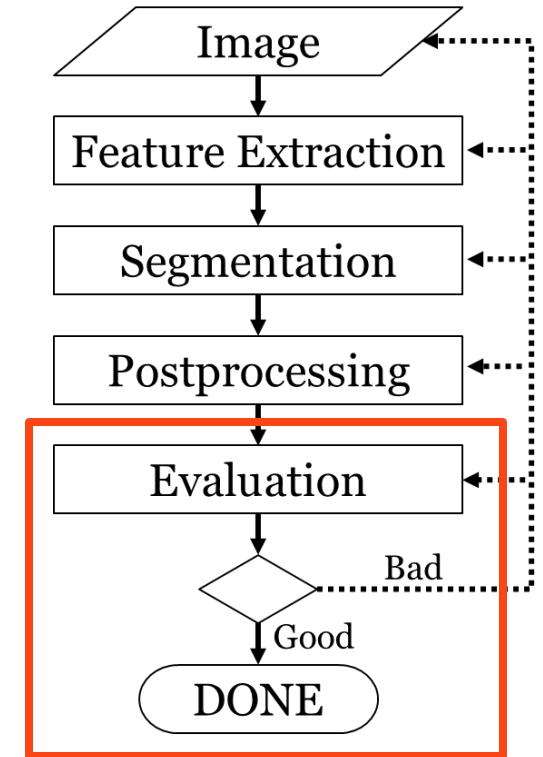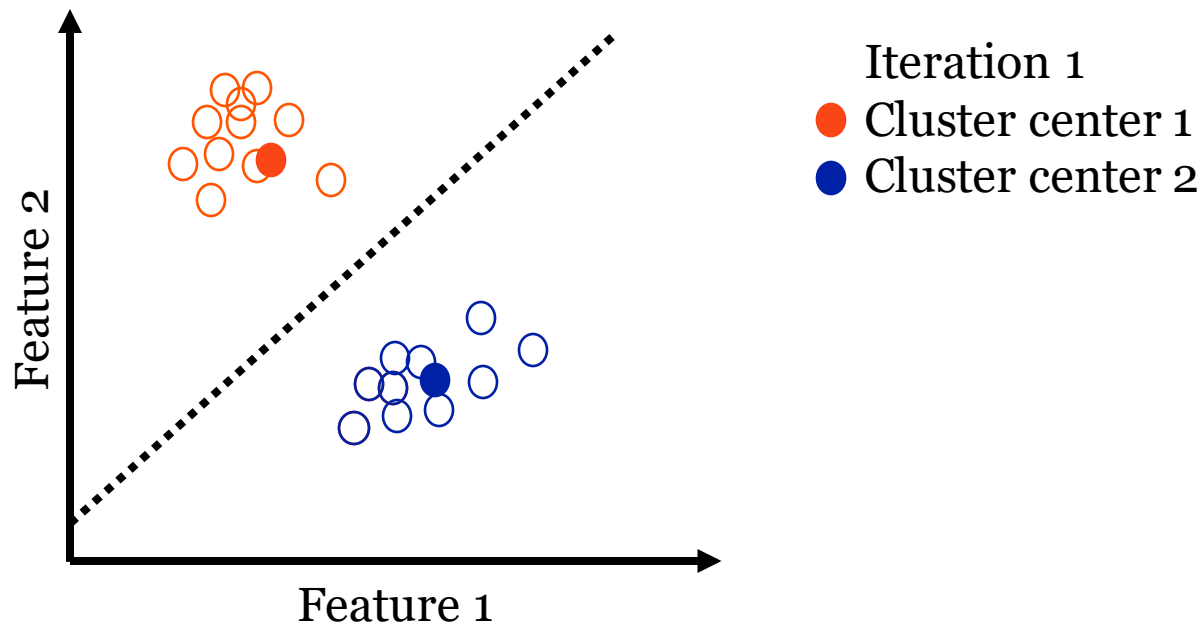
Extensions

- Feature Extraction
  - Other filters and features: rectangle detection
  - Feature selection: Linear Discriminant Analysis (LDA)
  - Feature normalization: Standard Scalar

- Segmentation
  - Other clustering algorithms: Spectral Clustering, Bisecting k-means

Experiment!

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Key Takeaways

1. Introduced Unsupervised Machine Learning
2. Feature Extraction: blurring, edges, corners
3. Segmentation: k-means clustering
4. Explainable AI: cluster centers
5. Extensions

Next: supervised learning