CS196

~~Data Science~~

Machine Learning

CS196

Intro to Machine Learning

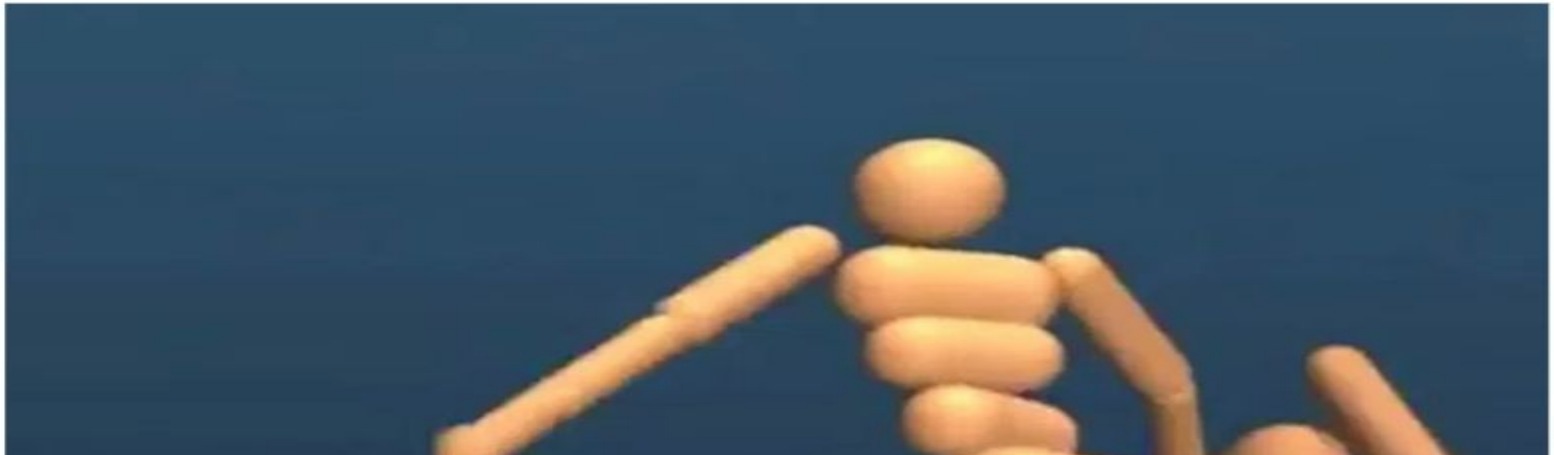

THIS IS YOUR MACHINE LEARNING SYSTEM?
YUP! YOU POUR THE DATA INTO THIS BIG PILE OF LINEAR ALGEBRA, THEN COLLECT THE ANSWERS ON THE OTHER SIDE.
WHAT IF THE ANSWERS ARE WRONG?
JUST STIR THE PILE UNTIL THEY START LOOKING RIGHT.
DATA
ANSWERS

Traditional Programming

Machine Learning

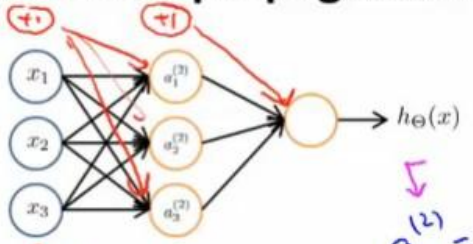
Beware — Google's AI is so smart it just taught itself to walk without any human help

Jimmy Nsubuga for Metro.co.uk Monday 17 Jul 2017 6:31 pm



How does it work?

Forward propagation: Vectorized implementation



$$a^{(1)} = x \qquad a_1^{(2)} = g(z_1^{(2)}) \qquad z_1^{(2)}$$

$$a_1^{(2)} = g(\Theta_{10}^{(1)} x_0 + \Theta_{11}^{(1)} x_1 + \Theta_{12}^{(1)} x_2 + \Theta_{13}^{(1)} x_3)$$
$$a_2^{(2)} = g(\Theta_{20}^{(1)} x_0 + \Theta_{21}^{(1)} x_1 + \Theta_{22}^{(1)} x_2 + \Theta_{23}^{(1)} x_3) \qquad z_2^{(2)}$$
$$a_3^{(2)} = g(\Theta_{30}^{(1)} x_0 + \Theta_{31}^{(1)} x_1 + \Theta_{32}^{(1)} x_2 + \Theta_{33}^{(1)} x_3) \qquad z_3^{(2)}$$

$$h_\Theta(x) = g(\Theta_{10}^{(2)} a_0^{(2)} + \Theta_{11}^{(2)} a_1^{(2)} + \Theta_{12}^{(2)} a_2^{(2)} + \Theta_{13}^{(2)} a_3^{(2)})$$

$a_0^{(2)} = 1$ $\quad a_3^{(2)} = g(z_3^{(2)})$

$$x = \begin{bmatrix} x_0 \\ x_1 \\ x_2 \\ x_3 \end{bmatrix} \qquad z^{(2)} = \begin{bmatrix} z_1^{(2)} \\ z_2^{(2)} \\ z_3^{(2)} \end{bmatrix}$$

$$z^{(2)} = \Theta^{(1)} a^{(1)}$$
$$a^{(2)} = g(z^{(2)}) \qquad \mathbb{R}^3 \quad \mathbb{R}^3$$

Add $a_0^{(2)} = 1.$ $\quad a^{(2)} \in \mathbb{R}^4$

$$z^{(3)} = \Theta^{(2)} a^{(2)}$$
$$h_\Theta(x) = a^{(3)} = g(z^{(3)})$$

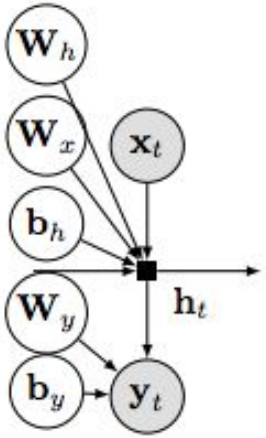
Andrew Ng


Caffe2


PYTORCH


scikit
learn


K
Keras




```
1  def rnn_cell(hprev, xt):
2    return tf.tanh(tf.dot(hprev, Wh) + tf.dot(xt, Wx) + bh)
3
4  Wh = Normal(mu=tf.zeros([H, H]), sigma=tf.ones([H, H]))
5  Wx = Normal(mu=tf.zeros([D, H]), sigma=tf.ones([D, H]))
6  Wy = Normal(mu=tf.zeros([H, 1]), sigma=tf.ones([H, 1]))
7  bh = Normal(mu=tf.zeros(H), sigma=tf.ones(H))
8  by = Normal(mu=tf.zeros(1), sigma=tf.ones(1))
9
10 x = tf.placeholder(tf.float32, [None, D])
11 h = tf.scan(rnn_cell, x, initializer=tf.zeros(H))
12 y = Normal(mu=tf.matmul(h, Wy) + by, sigma=1.0)
```

Figure 3: Bayesian RNN: **(left)** graphical model; **(right)** probabilistic program. The program has an unspecified number of time steps; it uses a symbolic for loop (`tf.scan`).

3.3 Stochastic Control Flow and Model Parallelism

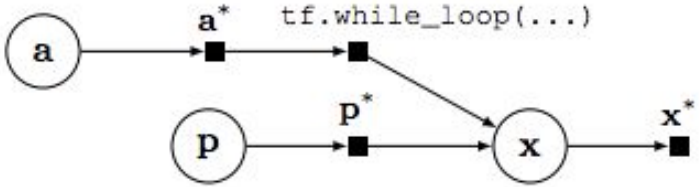
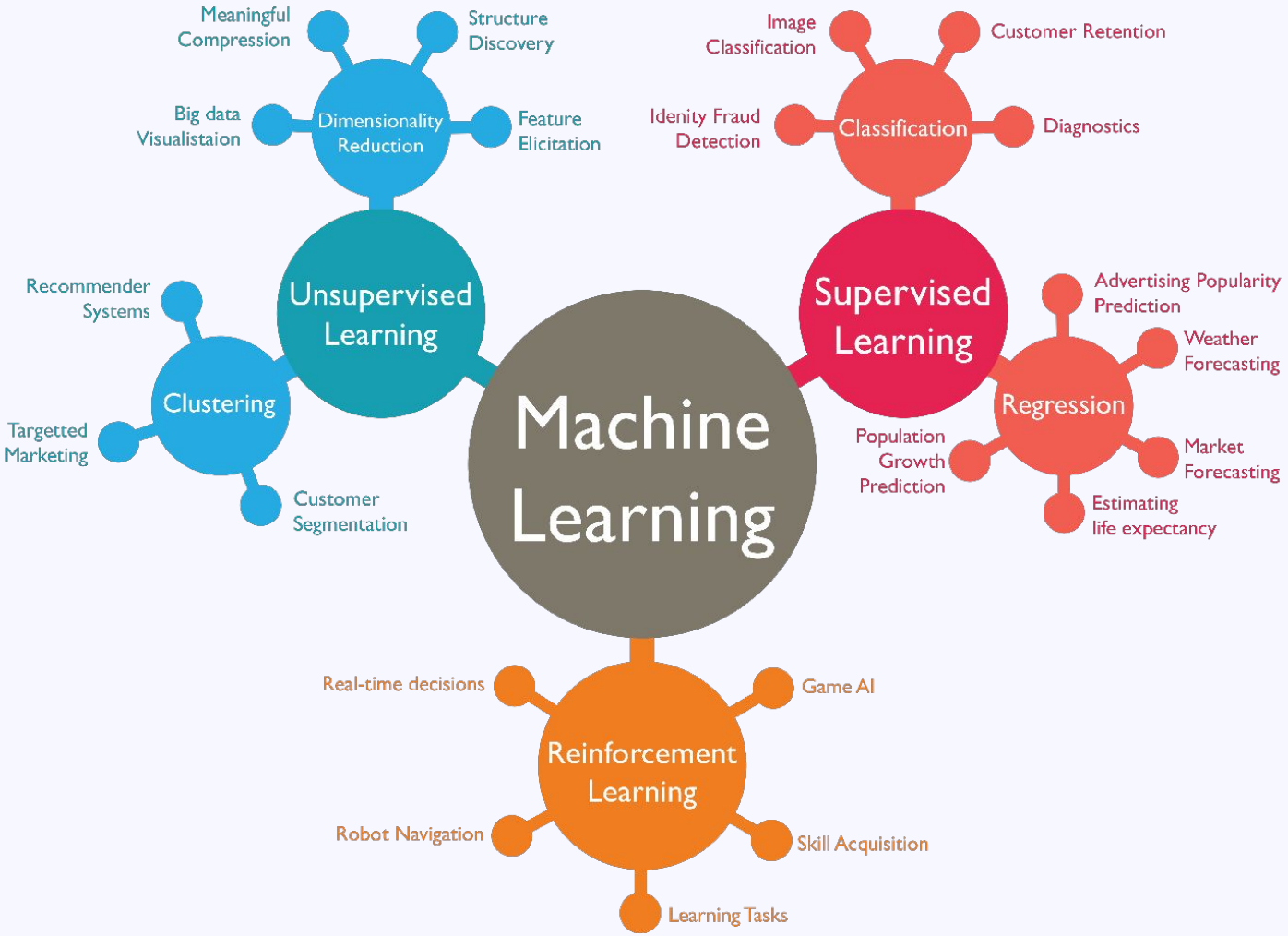
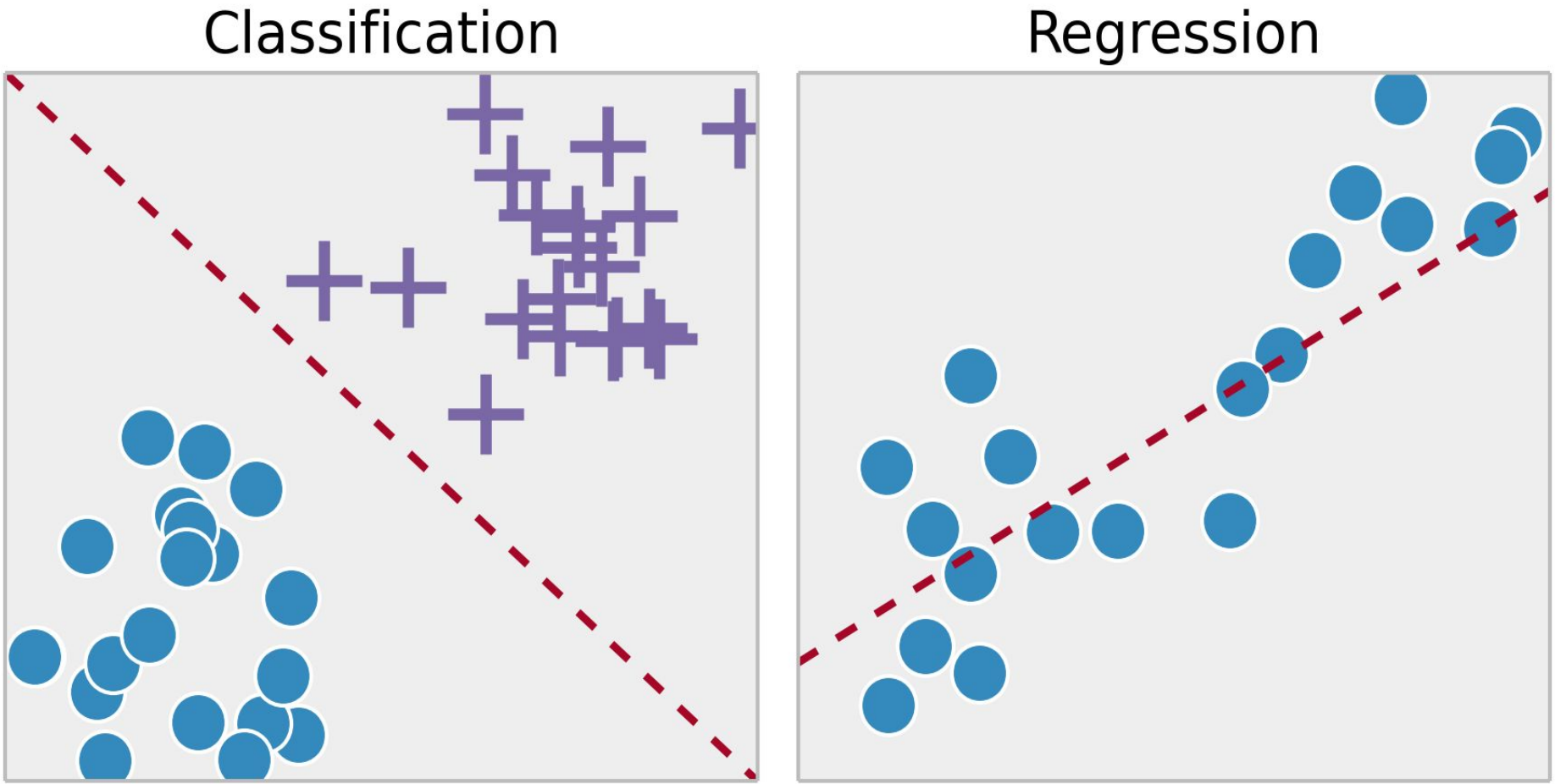
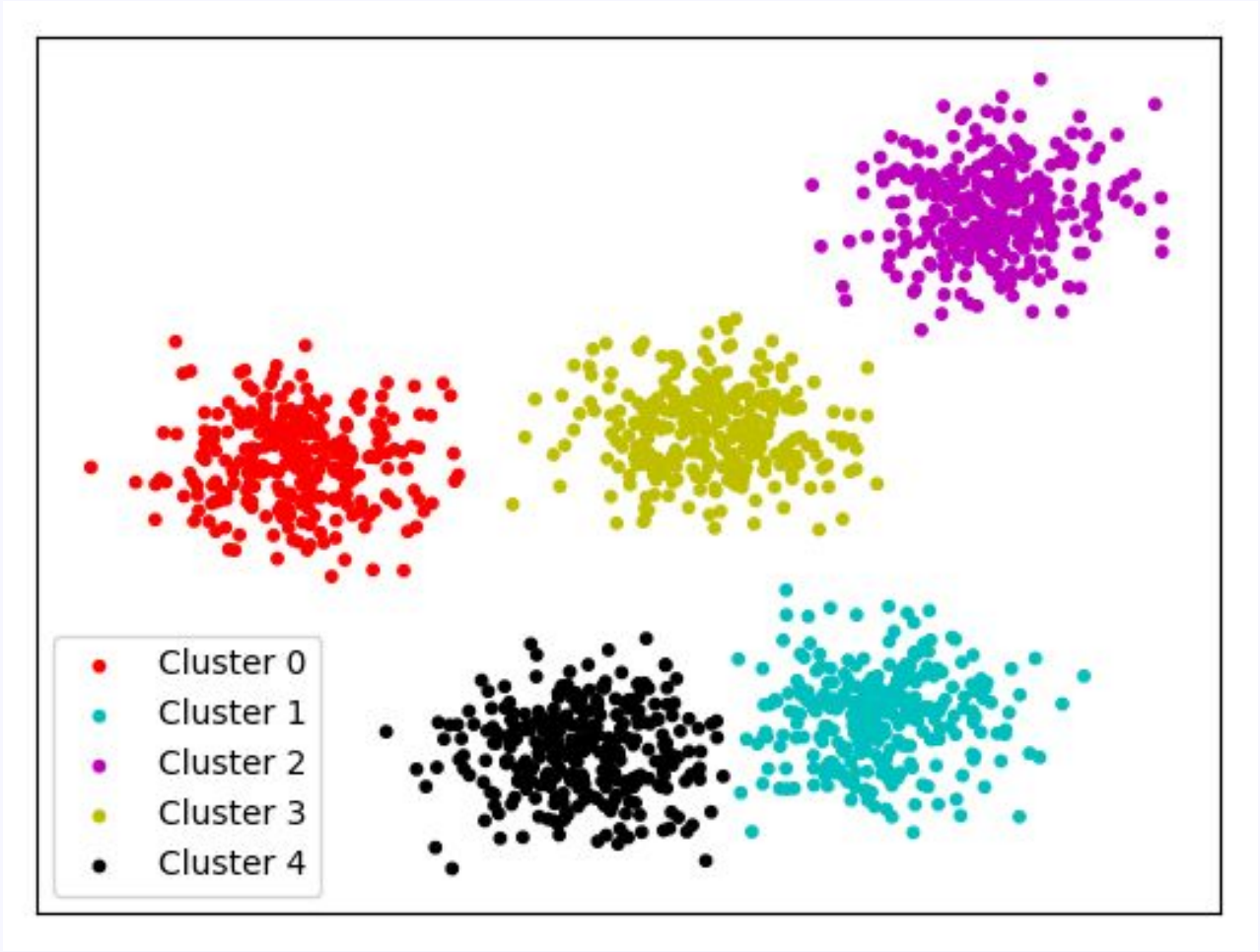


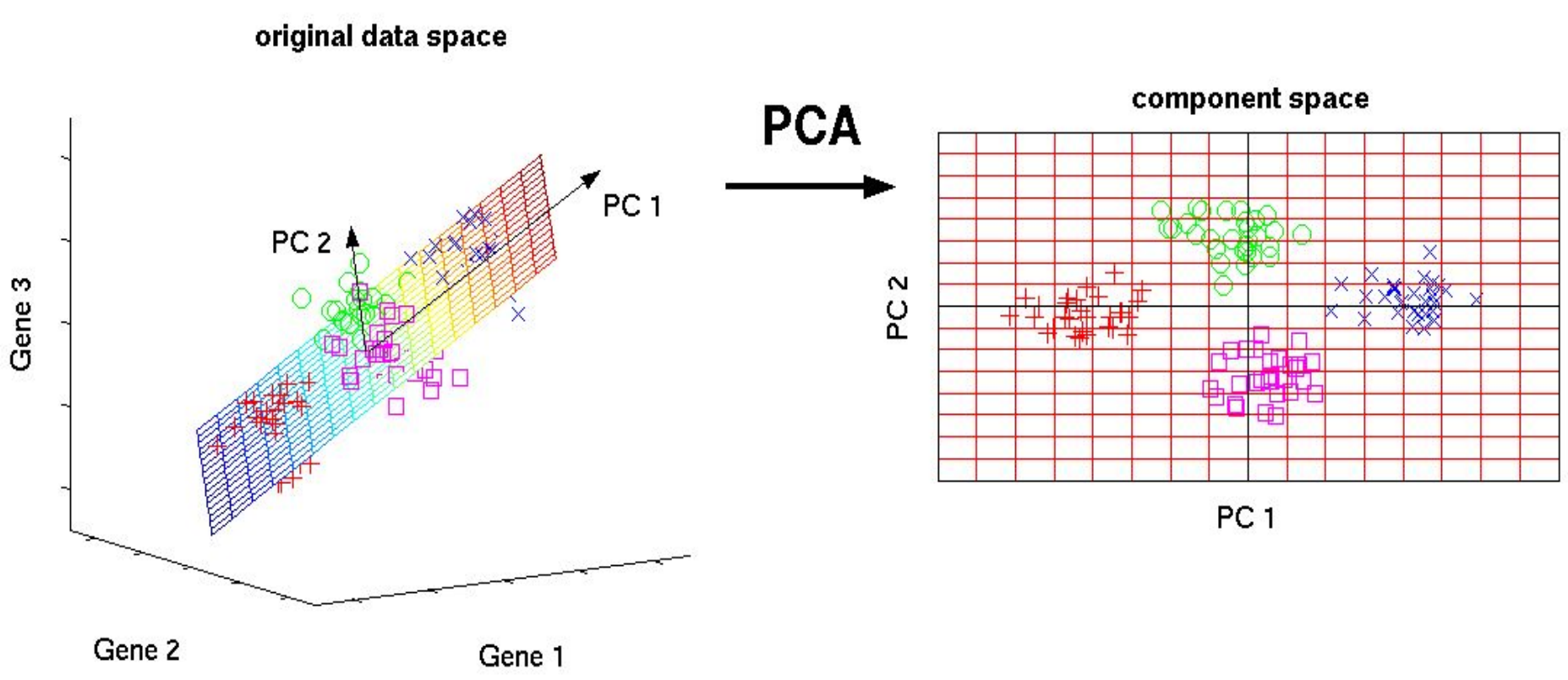
Figure 4: Computational graph for a probabilistic program with stochastic control flow.


Machine Learning
Unsupervised Learning
Dimensionality Reduction
Meaningful Compression
Structure Discovery
Big data Visualistaion
Feature Elicitation
Clustering
Recommender Systems
Targetted Marketing
Customer Segmentation
Supervised Learning
Classification
Image Classification
Customer Retention
Idenity Fraud Detection
Diagnostics
Regression
Advertising Popularity Prediction
Weather Forecasting
Population Growth Prediction
Market Forecasting
Estimating life expectancy
Reinforcement Learning
Real-time decisions
Game AI
Robot Navigation
Skill Acquisition
Learning Tasks

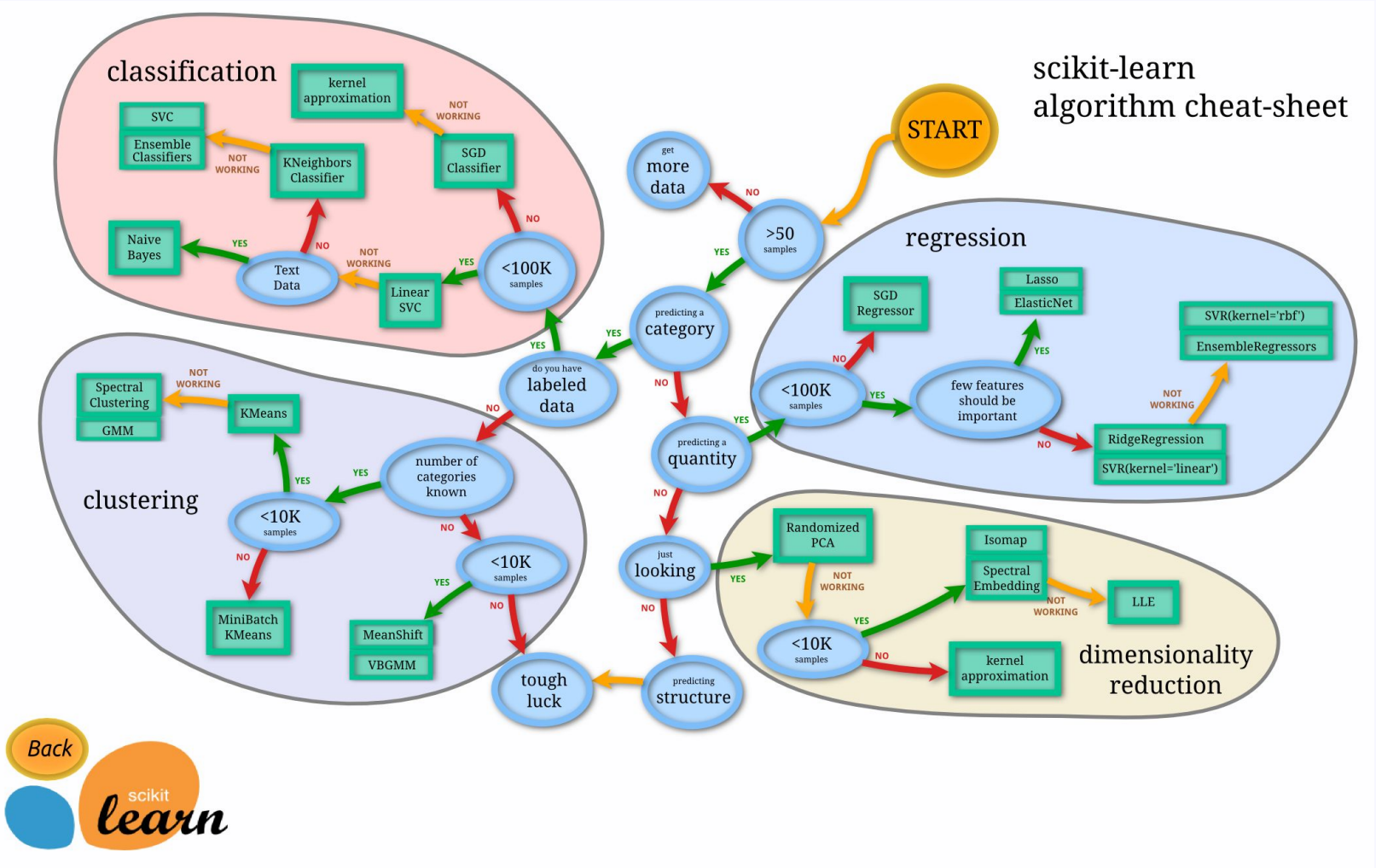
ML Tasks *Broad Categories*	***Supervised***	***Unsupervised***
Discrete	Classification Computer vision | Image Classification Speech, handwriting recognition Drug discovery	Clustering K-means, mean-shift Large-scale clustering problem Hierarchical clustering, GMM
Continuous	Regression Computer vision | Object Detection Linear, logistic regression	Reduction of Dimensionality PCA, LDA (Kernel) Density Estimation


Classification
Regression


Cluster 0
Cluster 1
Cluster 2
Cluster 3
Cluster 4


original data space
PC 1
PC 2
Gene 3
Gene 2
Gene 1
PCA
component space
PC 2
PC 1

scikit-learn algorithm cheat-sheet



ML as a Data Science Tool

- Best to start with a *large* dataset
- Can be used as an exploratory tool (see unsupervised learning)
- Data Scientists often create and train models that are then used in production services
  - i.e. Google's Inception image classifier

```
conda install scikit-learn
```