



## Learning Objectives

At the end of this module, students will be able to:

- Explain kernel regression as a non-parametric fit/prediction of data
- Set up an optimization problem for finding a state-vector machine classifier
- Explain the computation performed by a multilayer neural network
- Define the role of the activation function and give at least two examples
- Use backpropagation to train multilayer neural network classifiers

## Significance of Unit

Welcome to Unit 6. The title of this unit is nonlinear and nonparametric methods. This unit is covering some of the most advanced topic in machine learning that we are going to get to this semester. It is also the shortest unit. In this unit we are going to talk about things like neural networks, something called nonparametric regression, we are also going to talk about support vector machines. The concepts and principles that we have developed over the entire course are going to come to a culmination with this material because we are still interested in solving classification and data modeling problems, but now we have some pretty sophisticated and advanced tools we are capable of using. We're going to talk about nonparametric regression. Previously when we tried to fit data, we looked at the idea of trying to fit polynomials, that's a parametric regression because we have a parameterized model of a polynomial that we're trying to fit. In non-parametric regression we extend beyond the idea of specific functions and just consider what does it mean to fit something in a way that is smooth. We'll also extend those ideas of smooth fits to support vector machines where we try to find a classification problem, we try to find a smooth boundary that separates the classes and we're choosing that boundary to minimize the hinge loss while looking for an L2 regularized or Tikhonov solution. If you look back, we started with defining what we meant by multiplying a vector and a matrix and now we're here at this point where we're looking at some very sophisticated state of the art methods in machine learning. We're also going to talk about neural networks, which are inspired by the human brain. Given the material we've covered so far, we can understand the basics of neural networks in short order, and particularly we are going to spend some time looking at how to train a neural network for supervised learning using stochastic gradient descent. Neural networks have a lot of advanced ideas and tweaks and tricks to squeeze extra performance out of them. We're not going into that level of detail, rather we're going to focus on the fundamentals of how these things work and I think it's more straightforward than to dive deeper with specific tricks. You've come a long way and I trust you'll find this material both interesting and engaging as we wrap up the course, as well as something that will allow you to expand your studies in future courses or on your own into more advanced methods.

## Key Topics

1. Kernel regression and the kernel trick
2. Support vector machines
3. Neural networks and the backpropagation algorithm

## Learning Activities

- Instructional Unit 6.1
- Activity 21
- Instructional Unit 6.2
- Activity 22
- Instructional Units 6.3 and 6.4
- Activity 23

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- Activity 24
  - Unit 6 Practice Problems

### **Recommended Reading**

- None