

# Brain Computer Interfaces

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## Introduction

The windows, icons, menus, and pointers design paradigm was introduced in the 1980s.

Almost 30 years later this is still the main method of interacting with computers.

## What are BCIs

Brain Computers Interfaces (BCIs) are systems that allow a person to control a computer with their thoughts.

This is a wholly new way to interact with computers.

Originally used to assist the physically disabled communicate.

Now entertainment purposes are being explored.

## Electroencephalography

Electroencephalography (EEG) is a method of recording brain activity.

Scalp electrodes record the voltages put off by the brain.

EEG is has a very good temporal resolution but a poor spatial resolution.

## Event Related Potentials

### Definition

An event related potential (ERP) is a voltage reading over time from a certain area of the brain. These voltages are fired by the brain due to a certain thought or perception.

The brain is constantly firing ERPs.

Only some of these ERP's sources and meanings are known.

ERPs are usually named with a P or an N followed by a number.

The letter is for positive or negative voltage and the number is the latency.

## The P300 event

### P300

Generated in the parietal lobe. It is fired when a person sees something that is related to the task that person is trying to accomplish.

The P300 event is triggered involuntarily.

The P300 also appears very uniformly.

P300 is one of the most commonly used ERPs for BCIs.

## Calibration

Every brain is a little bit different.

A system can't recognize ERPs without a calibration process.

Machine learning algorithms are used to recognize the ERPs.

The calibration process involves triggering the ERP that the BCI is based on.



## Classification Algorithms

Information from the EEG is inputted into the algorithm as feature vectors.

The feature vectors can include amplitudes of the EEG signal, and time-frequency information.

## What makes a good classification algorithm?

For algorithms to be considered for ERP classification they must have these characteristics:

- Ability to handle noise in the input data
- Ability to handle a large feature vector
- Ability to deal with a large range of values
- Ability to train quickly on a small training set

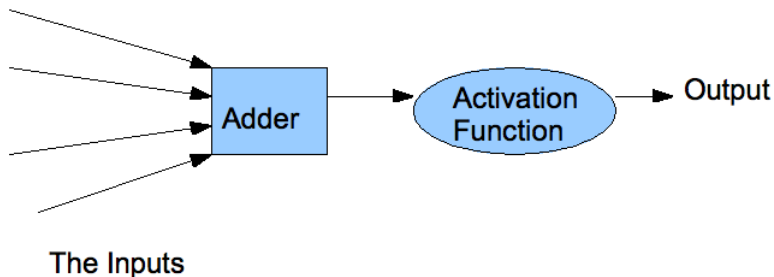
## Neural Networks

Neural networks are some of the most popular classification techniques.

They are made up of a collection of artificial neurons called McCulloch and Pitts neurons.

## McCulloch Pitts neurons

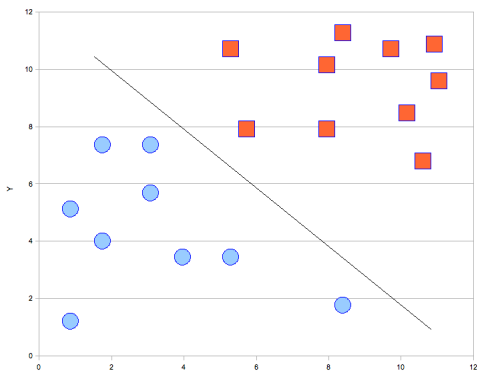
Neural networks are made up of weighted inputs, and nodes called McCulloch and Pitts neurons.



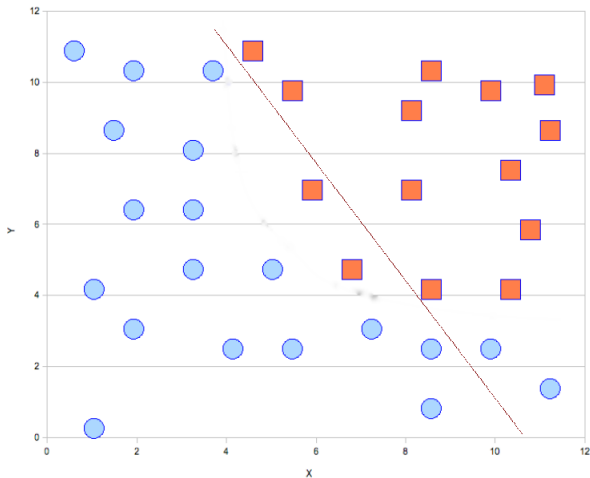
## Perceptron

The simplest neural network is made up of just one McCulloch Pitts neuron.

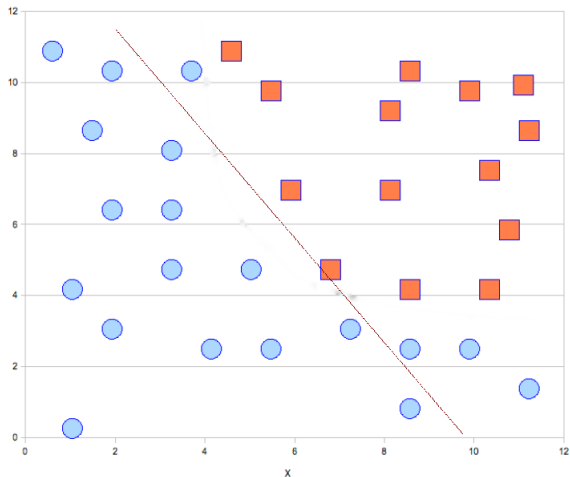
Perceptrons are limited to classifying problems that can be linearly separated.



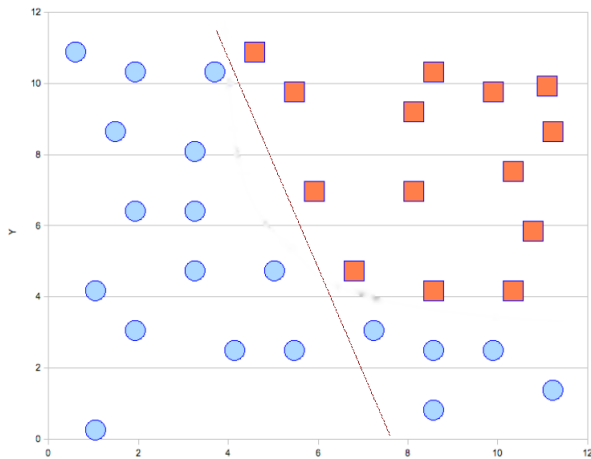
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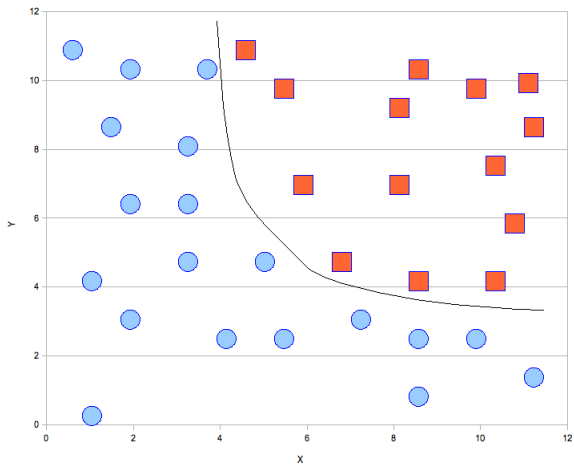


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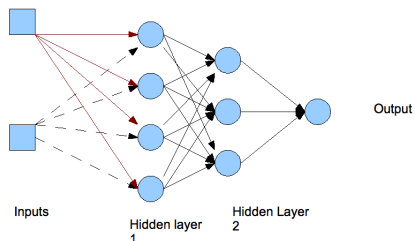


## Multilayer Perceptron (MLP)

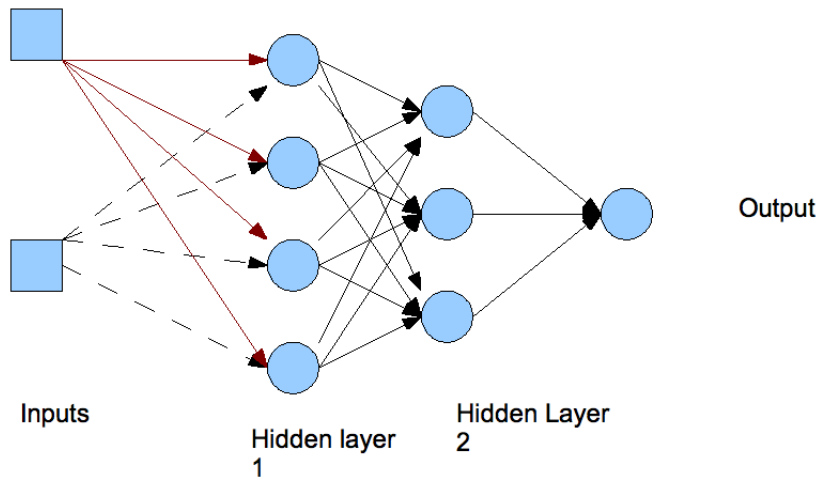
A MLP is a neural network that has one or more hidden layers and an output layer.

An MLP needs at most two hidden layers.

MLPs are one of the most common techniques used in BCIs.



# MLPs



## Training

Training a neural network involves changing the weights.

A weight is changed based on how much the node is off of the target value.

This process is known as backpropagation.

## Applications of BCI systems

Originally used to help people communicate with severe physical disabilities.

Now being used in other assistive technologies and for entertainment.

## Communication

The earliest BCI systems were P300 based systems that let people who were locked in or paralyzed communicate.



This concept has been expanded on by many researchers.

## The BrainBrowser

Took concepts from earlier systems and applied those concepts to a web browser.

The main challenge was adapting a 2D space to be navigated linearly.



## Ideas for Entertainment

BCIs for entertainment are a new area that hasn't been explored very much.

In the near future we could see commercial video games enhanced by the integration of BCI.

Eventually maybe we will see virtual environments entirely controllable by human thought.



## NeuroWander

NeuroWander is a game based on the fairy tale of Hansel and Gretel.

The user fills up "meditation" and "concentration" bars.

When both of the bars are filled up the player wins the game.



