## MSc - Data Mining

Topic 01 : Module Overview

Part 05: Optimisation Overview

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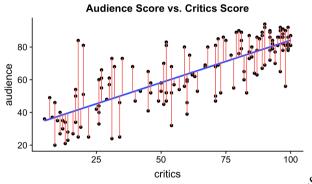
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Outline

## Machine learning meta-model: The Loss Function

- Machine learning is a large part of this module, but how does it actually work?
- Mathematically, we have a *function*, of one or more variables.
- Most machine learning problems can be formulated as finding values of that function that satisfy certain desirable properties
- Often that function is referred to as a *loss function*  $L \equiv L(M(\{D_i\}, a), \{\varepsilon_i\})$ , where
  - $\{D_i\}$ , with  $i=1,\ldots,m$  represents the *training* data (observations) used by the learner;
  - $\{\varepsilon_i\}$  represents the (unknown) errors in that training data;
  - $M(\{D_i\}, a)$  represents the model used to represent the data;
  - a represents one or more variables, that each take a special value when the required property holds
- Generally, the property we are looking for is that the value of the Loss Function should be as small as
  possible.

### **Example Loss Function**



Here the training data is  $\{D_i\} = \{x_i, y_i\}$  where  $x_i$  is the i<sup>th</sup> critics score and  $y_i$  is the corresponding audience score. A linear relationship  $M: y^* = a_0 + a_1 x$  is assumed and the errors are estimated by the difference between the predicted values (on the line) and the corresponding data values.

#### Source:

#### towardsdatascience.com

- The loss function is an expression computed from all the error estimates, giving a scalar output (a single number) with the property that the loss function decreases when the overall error decreases.
- So: minimising the loss function has the effect of fitting the line as close to the data as possible, equivalent to searching for the "best" values of  $a_0$  and  $a_1$  above.
- Many machine learning algorithms can be formulated in this way.

## Solving the optimisation problem

- Use trial and error unworkable unless there is a small, finite set to check
- Use function values only, compare them and use heuristics to guide the search
- Use derivatives and head downhill until you reach a valley (gradient descent)
- Use higher order derivatives to make more informed decisions

Enhancement: Apply constraints, e.g., when predicting weight, it cannot take negative values!

# Spotlight on Gradient Descent

