4 Practice Problems Quadratic Functions

Loss function

based on the quadratic loss function. The quadratic loss function is also used in linear-quadratic optimal control problems. In these problems, even in the

In mathematical optimization and decision theory, a loss function or cost function (sometimes also called an error function) is a function that maps an event or values of one or more variables onto a real number intuitively representing some "cost" associated with the event. An optimization problem seeks to minimize a loss function. An objective function is either a loss function or its opposite (in specific domains, variously called a reward function, a profit function, a utility function, a fitness function, etc.), in which case it is to be maximized. The loss function could include terms from several levels of the hierarchy.

In statistics, typically a loss function is used for parameter estimation, and the event in question is some function of the difference between estimated and true values for an instance of data. The concept, as old as Laplace, was reintroduced in statistics by Abraham Wald in the middle of the 20th century. In the context of economics, for example, this is usually economic cost or regret. In classification, it is the penalty for an incorrect classification of an example. In actuarial science, it is used in an insurance context to model benefits paid over premiums, particularly since the works of Harald Cramér in the 1920s. In optimal control, the loss is the penalty for failing to achieve a desired value. In financial risk management, the function is mapped to a monetary loss.

Quadratic equation

solutions of the equation, and roots or zeros of the quadratic function on its left-hand side. A quadratic equation has at most two solutions. If there is

In mathematics, a quadratic equation (from Latin quadratus 'square') is an equation that can be rearranged in standard form as

a

x

2

+

b

x

+

c

=

0

,

{\displaystyle ax^{2}+bx+c=0\,,}

where the variable x represents an unknown number, and a, b, and c represent known numbers, where a ? 0. (If a = 0 and b ? 0 then the equation is linear, not quadratic.) The numbers a, b, and c are the coefficients of the equation and may be distinguished by respectively calling them, the quadratic coefficient, the linear coefficient and the constant coefficient or free term.

The values of x that satisfy the equation are called solutions of the equation, and roots or zeros of the quadratic function on its left-hand side. A quadratic equation has at most two solutions. If there is only one solution, one says that it is a double root. If all the coefficients are real numbers, there are either two real solutions, or a single real double root, or two complex solutions that are complex conjugates of each other. A quadratic equation always has two roots, if complex roots are included and a double root is counted for two. A quadratic equation can be factored into an equivalent equation

a

x

2

+

b

x

+

c

=

a

(

x

?

r

)

(

x

?

s

)

=

0

{\displaystyle ax^{2}+bx+c=a(x-r)(x-s)=0}

where r and s are the solutions for x.

The quadratic formula

x

=

?

b

±

b

2

?

4

a

c

2

a

{\displaystyle x={\frac {-b\pm {\sqrt {b^{2}-4ac}}}{2a}}}

expresses the solutions in terms of a, b, and c. Completing the square is one of several ways for deriving the formula.

Solutions to problems that can be expressed in terms of quadratic equations were known as early as 2000 BC.

Because the quadratic equation involves only one unknown, it is called "univariate". The quadratic equation contains only powers of x that are non-negative integers, and therefore it is a polynomial equation. In particular, it is a second-degree polynomial equation, since the greatest power is two.

Linear–quadratic regulator

by a quadratic function is called the LQ problem. One of the main results in the theory is that the solution is provided by the linear–quadratic regulator

The theory of optimal control is concerned with operating a dynamic system at minimum cost. The case where the system dynamics are described by a set of linear differential equations and the cost is described by a quadratic function is called the LQ problem. One of the main results in the theory is that the solution is provided by the linear–quadratic regulator (LQR), a feedback controller whose equations are given below.

LQR controllers possess inherent robustness with guaranteed gain and phase margin, and they also are part of the solution to the LQG (linear–quadratic–Gaussian) problem. Like the LQR problem itself, the LQG problem is one of the most fundamental problems in control theory.

Non-uniform rational B-spline

span, the peak in the quadratic basis function is more distinct, reaching almost one. Conversely, the adjoining basis functions fall to zero more quickly

Non-uniform rational basis spline (NURBS) is a mathematical model using basis splines (B-splines) that is commonly used in computer graphics for representing curves and surfaces. It offers great flexibility and precision for handling both analytic (defined by common mathematical formulae) and modeled shapes. It is a type of curve modeling, as opposed to polygonal modeling or digital sculpting. NURBS curves are commonly used in computer-aided design (CAD), manufacturing (CAM), and engineering (CAE). They are part of numerous industry-wide standards, such as IGES, STEP, ACIS, and PHIGS. Tools for creating and editing NURBS surfaces are found in various 3D graphics, rendering, and animation software packages.

They can be efficiently handled by computer programs yet allow for easy human interaction. NURBS surfaces are functions of two parameters mapping to a surface in three-dimensional space. The shape of the surface is determined by control points. In a compact form, NURBS surfaces can represent simple geometrical shapes. For complex organic shapes, T-splines and subdivision surfaces are more suitable because they halve the number of control points in comparison with the NURBS surfaces.

In general, editing NURBS curves and surfaces is intuitive and predictable. Control points are always either connected directly to the curve or surface, or else act as if they were connected by a rubber band. Depending on the type of user interface, the editing of NURBS curves and surfaces can be via their control points (similar to Bézier curves) or via higher level tools such as spline modeling and hierarchical editing.

P versus NP problem

concept of NP-completeness is very useful. NP-complete problems are problems that any other NP problem is reducible to in polynomial time and whose solution

The P versus NP problem is a major unsolved problem in theoretical computer science. Informally, it asks whether every problem whose solution can be quickly verified can also be quickly solved.

Here, "quickly" means an algorithm exists that solves the task and runs in polynomial time (as opposed to, say, exponential time), meaning the task completion time is bounded above by a polynomial function on the size of the input to the algorithm. The general class of questions that some algorithm can answer in polynomial time is "P" or "class P". For some questions, there is no known way to find an answer quickly, but if provided with an answer, it can be verified quickly. The class of questions where an answer can be verified in polynomial time is "NP", standing for "nondeterministic polynomial time".

An answer to the P versus NP question would determine whether problems that can be verified in polynomial time can also be solved in polynomial time. If P ? NP, which is widely believed, it would mean that there are problems in NP that are harder to compute than to verify: they could not be solved in polynomial time, but the answer could be verified in polynomial time.

The problem has been called the most important open problem in computer science. Aside from being an important problem in computational theory, a proof either way would have profound implications for mathematics, cryptography, algorithm research, artificial intelligence, game theory, multimedia processing, philosophy, economics and many other fields.

It is one of the seven Millennium Prize Problems selected by the Clay Mathematics Institute, each of which carries a US$1,000,000 prize for the first correct solution.

Minkowski's question-mark function

question-mark function, denoted ?(x), is a function with unusual fractal properties, defined by Hermann Minkowski in 1904. It maps quadratic irrational numbers

In mathematics, Minkowski's question-mark function, denoted ?(x), is a function with unusual fractal properties, defined by Hermann Minkowski in 1904. It maps quadratic irrational numbers to rational numbers on the unit interval, via an expression relating the continued fraction expansions of the quadratics to the binary expansions of the rationals, given by Arnaud Denjoy in 1938. It also maps rational numbers to dyadic rationals, as can be seen by a recursive definition closely related to the Stern–Brocot tree.

Knapsack problem

Optimization Methods for Quadratic Knapsack Problems". J Optim Theory Appl. 151 (2): 241–259. doi:10.1007/s10957-011-9885-4. S2CID 31208118. Gallo, G

The knapsack problem is the following problem in combinatorial optimization:

Given a set of items, each with a weight and a value, determine which items to include in the collection so that the total weight is less than or equal to a given limit and the total value is as large as possible.

It derives its name from the problem faced by someone who is constrained by a fixed-size knapsack and must fill it with the most valuable items. The problem often arises in resource allocation where the decision-makers have to choose from a set of non-divisible projects or tasks under a fixed budget or time constraint, respectively.

The knapsack problem has been studied for more than a century, with early works dating as far back as 1897.

The subset sum problem is a special case of the decision and 0-1 problems where for each kind of item, the weight equals the value:

w

i

=

v

i

{\displaystyle w_{i}=v_{i}}

. In the field of cryptography, the term knapsack problem is often used to refer specifically to the subset sum problem. The subset sum problem is one of Karp's 21 NP-complete problems.

Ant colony optimization algorithms

for Quadratic Assignment Problems". CiteSeerX 10.1.1.47.5167. • Stützle, Thomas (July 1997). MAX-MIN Ant System for Quadratic Assignment Problems (Technical

In computer science and operations research, the ant colony optimization algorithm (ACO) is a probabilistic technique for solving computational problems that can be reduced to finding good paths through graphs. Artificial ants represent multi-agent methods inspired by the behavior of real ants.

The pheromone-based communication of biological ants is often the predominant paradigm used. Combinations of artificial ants and local search algorithms have become a preferred method for numerous optimization tasks involving some sort of graph, e.g., vehicle routing and internet routing.

As an example, ant colony optimization is a class of optimization algorithms modeled on the actions of an ant colony. Artificial 'ants' (e.g. simulation agents) locate optimal solutions by moving through a parameter space representing all possible solutions. Real ants lay down pheromones to direct each other to resources while exploring their environment. The simulated 'ants' similarly record their positions and the quality of their solutions, so that in later simulation iterations more ants locate better solutions. One variation on this approach is the bees algorithm, which is more analogous to the foraging patterns of the honey bee, another social insect.

This algorithm is a member of the ant colony algorithms family, in swarm intelligence methods, and it constitutes some metaheuristic optimizations. Initially proposed by Marco Dorigo in 1992 in his PhD thesis, the first algorithm was aiming to search for an optimal path in a graph, based on the behavior of ants seeking a path between their colony and a source of food. The original idea has since diversified to solve a wider class of numerical problems, and as a result, several problems have emerged, drawing on various aspects of the behavior of ants. From a broader perspective, ACO performs a model-based search and shares some similarities with estimation of distribution algorithms.

Interior-point method

\\\end{aligned}}} We assume that the constraint functions belong to some family (e.g. quadratic functions), so that the program can be represented by a

Interior-point methods (also referred to as barrier methods or IPMs) are algorithms for solving linear and non-linear convex optimization problems. IPMs combine two advantages of previously-known algorithms:

Theoretically, their run-time is polynomial—in contrast to the simplex method, which has exponential run-time in the worst case.

Practically, they run as fast as the simplex method—in contrast to the ellipsoid method, which has polynomial run-time in theory but is very slow in practice.

In contrast to the simplex method which traverses the boundary of the feasible region, and the ellipsoid method which bounds the feasible region from outside, an IPM reaches a best solution by traversing the interior of the feasible region—hence the name.

Newton's method

and that f is a smooth function. So, even before any computation, it is known that any convergent Newton iteration has a quadratic rate of convergence.

In numerical analysis, the Newton–Raphson method, also known simply as Newton's method, named after Isaac Newton and Joseph Raphson, is a root-finding algorithm which produces successively better approximations to the roots (or zeroes) of a real-valued function. The most basic version starts with a real-valued function f, its derivative f?, and an initial guess x0 for a root of f. If f satisfies certain assumptions and the initial guess is close, then

x

1

=

x

0

?

f

(

x

0

)

f

?

(

x

0

)

{\displaystyle x_{1}=x_{0}-{\frac {f(x_{0})}{f'(x_{0})}}}

is a better approximation of the root than x0. Geometrically, (x1, 0) is the x-intercept of the tangent of the graph of f at (x0, f(x0)): that is, the improved guess, x1, is the unique root of the linear approximation of f at the initial guess, x0. The process is repeated as

x

n

+

1

=

x

n

?

f

(

x

n

)

f

?

(

x

n

)

{\displaystyle x_{n+1}=x_{n}-{\frac {f(x_{n})}{f'(x_{n})}}}

until a sufficiently precise value is reached. The number of correct digits roughly doubles with each step. This algorithm is first in the class of Householder's methods, and was succeeded by Halley's method. The method can also be extended to complex functions and to systems of equations.

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