# UNIVERSITÀ DELLA SVIZZERA ITALIANA

# FACULTY OF COMPUTER SCIENCE

# Master in Artificial Intelligence

# Topic: Computational Geometry [2014]

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# Summary

Computational geometry is a branch of computer science devoted to the study of algorithms which can be stated in terms of geometry. Some purely geometrical problems arise out of the study of computational geometric algorithms, and such problems are also considered to be part of computational geometry.

The main impetus for the development of computational geometry as a discipline was progress in computer graphics, computer-aided design, and manufacturing (CAD/CAM), but many problems in computational geometry are classical.

Other important applications of computational geometry include robotics (motion planning and visibility problems), geographic information systems (GIS) (geometrical location and search, route planning), integrated circuit design (IC geometry design and verification), computer-aided engineering (CAE) (programming of numerically controlled (NC) machines). The main branches of computational geometry are:

1. Combinatorial computational geometry.
2. Numerical computational geometry.

# Combinatorial computational geometry

The primary goal of research in combinatorial computational geometry is to develop efficient algorithms and data structures for solving problems stated in terms of basic geometrical objects: points, line segments, polygons, polyhedral, etc. Some of these problems seem so simple that they were not regarded as problems at all until the advent of computers.

# Problem classes

The core problems in computational geometry may be classified in different ways, according to various criteria. The following general classes may be distinguished.

# Static problems

In the problems of this category, some input is given and the corresponding out- put needs to be constructed or found.

# Geometric query problems

In geometric query problems, commonly known as geometric search problems, the input consists of two parts: the search space part and the query part, which varies over the problem instances. The search space typically needs to be preprocessed, in a way that multiple queries can be answered efficiently.

# Dynamic problems

Yet another major class is dynamic problems, in which the goal is to find an efficient algorithm for finding a solution repeatedly after each incremental modification of the input data (addition or deletion of input geometric elements). Algorithms for problems of this type typically involve dynamic data structures.

# Variations

Some problems may be treated as belonging to either of the categories, depending on the context. For example, consider the following problem.

# Numerical computational geometry

This branch is also known as geometric modeling and computer-aided geometric design (CAGD). Core problems are curve and surface modeling and representation. The most important instruments here are parametric curves and parametric surfaces, such as Bezier curves, spline curves, and surfaces. An important non-parametric approach is a level set method. Application areas include shipbuilding, aircraft, and automotive industries.