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TOPOLOGY: ITS HISTORY AND ITS SCOPE IN OTHR SCIENCES

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Abstract: *In this research paper, I would like to discuss historical background of topology and its Applications in industries through different areas of sciences such as Biology, Computer Science, Chemistry, Physics, Business Economics and Engineering*

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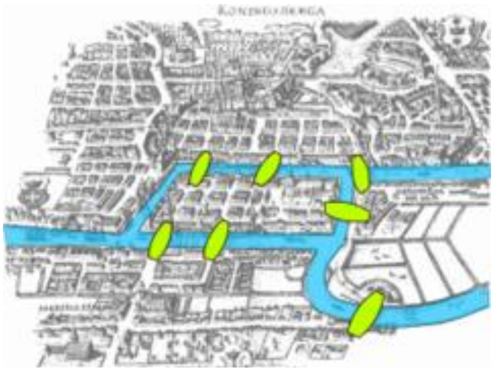
HISTORY

Topology, as a well-defined mathematical discipline, originates in the early part of the twentieth century, but some isolated results can be traced back several centuries. Among these are certain questions in geometry investigated by **Leonhard Euler**. His 1736 paper on the **Seven Bridges of Königsberg** is regarded as one of the first practical applications of topology. On 14 November 1750 Euler wrote to a friend that he had realised the importance of the *edges* of a **polyhedron**. This led to his **polyhedron formula**, $V - E + F = 2$ (where V, E and F respectively indicate the number of vertices, edges and faces of the polyhedron). Some authorities regard this analysis as the first theorem, signalling the birth of topology.



APPLICATIONS

Biology

<u>Knot theory</u>: - A branch of topology is used in biology to study the effects of certain enzymes on DNA. In recent years, topologist have developed the discrete geometric language of knots to a fine mathematical art one of the most interesting new scientific application of topology is the use of knot theory in analysis of DNA experiments. One of the important issues in molecular biology in the 3-dimensional structure of proteins and DNA solution in the cell and

relationship between structure and functions. Generally protein and DNA structures are determined by X-rays crystallization and the manipulation required preparing a specimen for electron microscope. The DNA molecules are long and thin and the packing of DNA molecules in the cell nucleus is very complex. The biological solution to this entanglement problem is the existence of enzymes, which convert DNA from one topological form to another and appeared to have a performed role in the central genetic events of DNA replication, recombination and transcription.

These enzymes cut, twist, and reconnect the DNA, causing knotting with observable effects such as slower electrophoresis. Topology is also used in evolutionary biology to represent the relationship between phenotype and genotype. Phenotypic forms that appear quite different can be separated by only a few mutations depending on how genetic changes map to phenotypic changes during development.

Computer Science

Topological data analysis uses techniques from algebraic topology to determine the large scale structure of a set (for instance, determining if a cloud of points is spherical or toroidal). The main method used by topological data analysis is:

1. Replace a set of data points with a family of simplicial complexes, indexed by a proximity parameter.
2. Analyse these topological complexes via algebraic topology — specifically, via the theory of persistent homology.
3. Encode the persistent homology of a data set in the form of a parameterized version of a Betti number, which is called a **barcode**

The problem of the minimal number of conditional statements in an algorithm, to solve a problem is particularly well suited for the topological approach.

Physics

In physics, topology is used in several areas such as condensed matter physics, quantum field theory and physical cosmology.

The topological dependence of mechanical properties in solids is of interest in disciplines of mechanical engineering and materials science. Electrical and mechanical properties depend on the arrangement and network structures of molecules and elementary units in

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materials. The compressive strength of crumpled topologies is studied in attempts to understand the high strength to weight of such structures that are mostly empty space. Topology is of further significance in Contact mechanics where the dependence of stiffness and friction on the dimensionality of surface structures is the subject of interest with applications in multi-body physics. In fact; topology has intrigued particle physicist for a long time.

A topological quantum field theory (or topological field theory or TQFT) is a quantum field theory that computes topological invariants.

Although TQFTs were invented by physicists, they are also of mathematical interest, being related to, among other things, knot theory and the theory of four-manifolds in algebraic topology, and to the theory of moduli spaces in algebraic geometry.

Donaldson, Jones, Witten, and Kontsevich have all won Fields Medals for work related to topological field theory.

The topological classification of Calabi-Yau manifolds has important implications in string theory, as different manifolds can sustain different kinds of strings.

In cosmology, topology can be used to describe the overall shape of the universe] This area is known as space-time topology.

Chemistry

In **topology** provides a convenient way of describing and predicting the molecular structure within the constraints of three-dimensional (3-D) space. Given the determinants of chemical bonding and the chemical properties of the atoms, topology provides a model for explaining how the atoms ethereal wave functions must fit together. Molecular topology is a part of mathematical chemistry dealing with the algebraic description of chemical compounds so allowing a unique and easy characterization of them.

Topology is insensitive to the details of a scalar field, and can often be determined using simplified calculations. Scalar fields such as electron density, Madelung field, covalent field.

The chemists have been trying continuously to synthesize and measure molecules with topological interesting structures. The most important tools in the topological method of making chemical predictions are known as indices. They derive from algorithms of procedures that convert the topological structure of a molecule into a single characteristic number. The topological method has now found applications beyond the simple prediction of chemical properties. It has the potential to help in modelling the behaviour of gases, liquids and solids and of both organic and inorganic species; in developing new anaesthetics and psychoactive drugs; in predicting the extent to which the various pollutants might spread in the environment and the harm they might do once they spread; in estimating the cancer causing potential of certain chemicals and even in developing beer with a well-balanced taste.

Business Economics

Topology has the tremendous effects on developments in economics. The study of conflicts of interest among the individuals makes economics interesting and mathematically complex. The space of all individual preferences that defines their optimization problems, is topologically non trivial and that is the topologically complexity which is responsible for the impossibility of treating several individual preferences as if they were one. In general, it is not possible to define a single optimization problem. Due to the complexity arising from simultaneous optimization problems, economics differs from physics where many fundamental relations derive from a single optimization problem.

Engineering

Topology has also found applications in engineering. Topology optimization (TO) is a mathematical method that optimizes material layout within a given design space, for a given set of loads, boundary conditions and constraints with the goal of maximising the performance of the system. TO is different from shape optimization in the sense that the design can attain any shape within the design space, instead of dealing with predefined configurations.. The application of the topology optimization method in various fields of engineering may significantly improve design cost and quality which is important in global competition. We would like to spread the concept and ideas of topology optimization among designers and students, allowing them to try the topology optimization approach on their own specific problems.

In particular, topological techniques are used in several robotics applications. The various possible positions of a robot can be described by a manifold called configuration space. In the area of motion planning, one finds paths between two points in configuration space. These paths represent a motion of the robot's joints and other parts into the desired location and pose.

REFERENCES

1. Brown, David : Topology and Chemistry; Structural Chemistry Volume 13, Numbers 3–4, 339–355, doi:10.1023/A:1015872125545
2. Francl, Michelle; Stretching topology Nature Chemistry 1, 334–335 (2009) doi:10.1038/nchem.302
3. Molecular topology
4. Rouvray, D. H.; A rationale for the topological approach to chemistry; Journal of Molecular Structure: THEOCHEM Volume 336, Issues 2–3, 30 June 1995, pages 101–114
5. The Knot Book: An Elementary Introduction to the Mathematical Theory of Knots. American Mathematical Society. ISBN 0-8218-3678-1
6. Barble M R Stadler; et al. "The Topology of the Possible: Formal Spaces Underlying Patterns of Evolutionary Change". Journal of Theoretical Biology. 213: 241-274. PMID 11894994. doi:10.1006/jtbi.2001.2423.
7. Gunnar Carlsson (April 2009). "Topology and data"(PDF). Bulletin (New Series) of the American Mathematical Society. 46 (2): 255–308. doi:10.1090/S0273-0979-09-01249-X.
8. "The Nobel Prize in Physics 2016". Nobel Foundation. 4 October 2016. Retrieved 12 October 2016.
9. John J. Craig, Introduction to Robotics: Mechanics and Control, 3rd Ed. Prentice-Hall, 2004
10. Michael Farber, Invitation to Topological Robotics, European Mathematical Society, 2008