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# TOPOLOGICAL ORGANIZATION OF INHABITANTS ACTIVITY IN PRIMARY VISUAL CORTEX

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# Topological Organization of Inhabitants Activity in Primary Visual Cortex

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***Abstract* – *Information in the cortex is widely believed to be represented by the joint activity of neuronal populations. Developing insights into the nature of these representations is a necessary first step in our quest to understanding cortical computation. Our analyses confirm that spontaneous activity is highly structured and statistically different from noise. Our analyses confirm that spontaneous activity is highly structured and statistically different from noise.***

***Keywords: Bitopological, Space, Pairs, Topologies, Compact, Cover, Regular, Graph***

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## INTRODUCTION

Information in the cortex is thought to be represented by the joint activity of neurons. A more principled approach for analyzing the structure of population activity was introduced in a theoretical study by Goldberg et al (2004). These investigators studied the possibility of using of a single real-valued statistic, the correlation coefficients between one of the measured states (the 'reference state') and the remaining ones, to differentiate among the presence of a single background state and the presence of a ring attractor. The basic idea is that the shape of this distribution conveys information about the encoding. To illustrate this point they derived the distribution of correlation coefficients in a case where multiple features are mapped to a high-dimensional unit sphere (a scenario they referred to as a 'combinatorial encoding') and when different variables map into separate manifolds (a scenario they called 'unary encoding'). The topological structure of activity patterns when the cortex is spontaneously active is similar to those evoked by natural image stimulation and consistent with the topology of a two sphere.

## ALGEBRAIC TOPOLOGY

Algebraic Topology is a sub branch of Topology. The motivating insight behind topology is that some geometric problems depend not on the exact shape of the objects involved, but rather on the way they are put together. For example, the square and the circle have many properties in common: they are both one dimensional object (from a topological point of view) and both separate the plane into two parts, the part inside and the part outside. Another way of putting it is that topology attempts to understand the global connectivity of an object by considering how the object is connected locally. Objects are assigned classes such that two objects in the same class exhibit the same connectivity. For example, the square and the circle are be in the same class, but the sphere and the circle are not.

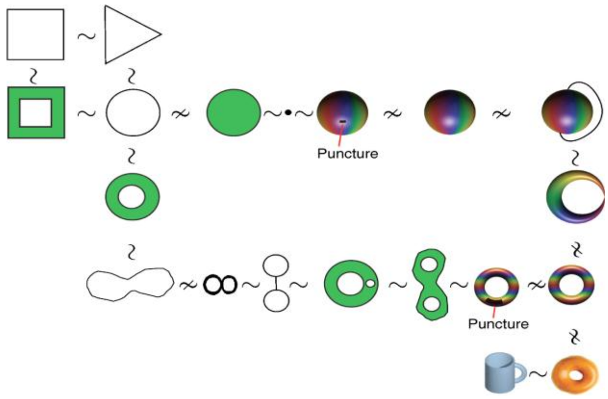
Algebraic Topology studies properties of objects (in technical terms: topological spaces) and maps between them, in particular, it identifies intrinsic properties of objects by transforming them in certain ways and observing which properties do not change. We call these properties invariants of the space. The kind of transformations that we will be interested in are called homotopy equivalences. we are representing graphical examples which attempt to convey the idea behind the definition.

Informally, Algebraic Topology, because of its use of homotopy equivalences, is sometimes referred to as “rubber sheet geometry" in the sense that it is oblivious to the fact that by stretching the same piece of rubber one can obtain different looking objects, all it cares about is that it was the same piece of rubber that was deformed in certain ways to produce differently looking objects. It therefore is concerned with certain intrinsic properties of objects.

When two spaces X and Y are related by such a transformation, we will say that X and Y are (homotopy) equivalent and write X ~ Y . When no such transformation exists between X and Y we write X ~/ Y. Below diagram shows examples of spaces that are and are not homotopy equivalent.

**Description of topological analysis:**

Consider a world where objects are made of elastic rubber. Two objects are considered equivalent if they can be deformed into each other without tearing the material. If such a transformation between X and Y exists, we say they are topologically equivalent and write X ~ Y; this notion of equivalence is illustrated in the following diagram.




This notion of counting holes of different dimensions is formalized by the definition of Betti numbers. The Betti numbers of an object X can be arranged in a sequence, b(X) = (b0, b1, b2, I), where b0 represents the number of connected components, b1 represents the number of one dimensional holes, b2 the number of two-dimensional holes, and so forth. An important property of Betti sequences is that if two objects are topologically equivalent they share the same Betti sequence.

(1,0,0,0,…) (1,1,0,0,…) (1,2,1,0,…)

(1,2,1,0,…) (1,0,1,0,…)

Betti numbers provide a signature of the underlying topology. Illustrated in the !gure are !ve simple objects (topological spaces) together with their Betti number signatures: (a) a point, (b) a circle, (c) a hollow torus, (d) a Klein bottle, and (e) a hollow sphere. For the case of the torus (c), the !gure shows three loops on its surface. The red loops are "essential" in that they cannot be shrunk to a point, nor can they be deformed one into the other without tearing the loop. The green loop, on the other hand, can be deformed to a point without any obstruction. For the torus, therefore, we have b1 = 2. For the case of the sphere, the loops shown (and actually all loops on the sphere) can be contracted to points, which is re"ected by the fact that b1 = 0. Both the sphere and the torus have b2 = 1, this is due to the fact both surfaces enclose a part of space (a void).

**Topological perspective on graph theory**

One of the most basic and important building blocks of graph theory is the notion of "connectedness". The same word also has a very important meaning in the field of general topology; indeed, arguably the latter subject grew precisely out of the efforts of several mathematicians to give the right formalization for concepts like "continuity", "convergence", "dimension" and, not least, connectedness. Although formally the two concepts are very different, one depending on finite paths and the other on open sets, the intuition behind the two versions of connectedness is essentially the same, and few will dispute that any link between graph theory and topology should at least reconcile them, if not be entirely dictated by this objective. In fact the usual way of modeling a graph as a topological object does achieve this, albeit in a way which, we feel, is not entirely satisfactory.

Traditionally, a graph is modeled as a one-dimensional cell-complex2, with open arms for edges and points for vertices, the neighbourhoods of a "vertex" being the sets containing the vertex itself and a union of corresponding "tails" of every "edge" (arc) incident with the vertex. If the graph is planar, this is equivalent to taking the subspace topology inherited from the Euclidean plane by an appropriate "drawing" of the graph. If the graph is finite, one can always place the vertices in three-dimensional Euclidean space, and join up pairs of adjacent vertices by pairwise disjoint open arcs (whose accumulation points are the two adjacent vertices) so that the union of the arcs together with the set of vertices inherits the topology of a cell-complex with the above restriction. Also, in the finite case, this concept coincides with that of a graph in continuum theory

## RELAXING THE COMPATIBILITY REQUIREMENT

A class of topological space retains some of the properties of the classical topology of a simple graph.

**Definition 1:**

A topologized graph is a topological space X such that

- every singleton is open or closed;
- $\forall x \in X, |\partial(x)| \leq 2$.

Note that, in any S1 space, the set E of points which are not closed is open, and therefore its complement, V, is closed. Thus the closure of any subset A of E, in particular any singleton, is of the form $E \cup B$ for some $B \subseteq V$, and $\partial$ (A) = B.

Therefore a "topologized graph" has an underlying combinatorial structure, as well as a topological one.

## CONCLUSION:

We have analyze that computational topology can help address basic questions about the encoding of in sequence by neuronal populations. The result of the analysis is a topological characterization of the activity, which provides qualitative information about its structure, such as the number of clusters and loops in the activity patterns. The paper contains about the topological perspective on graph theory. A graph consists of vertices and edges. We have mentioned relaxing the compatibility requirement that we can meaningfully apply to our spaces. An edge is an open singleton whose boundary consists of the incident vertices.

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