Characterizing T-cell Dynamics using Topological Data Analysis

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T-cells are key components of the immune and lymphatic system, responsible for triggering immune responses that combat the entry of foreign entities into the human body. Their effectiveness is largely determined by their cooperative motility - how quickly they can help each other move through crowded environments. Prior work (figure below) studied their movement under a simplified two-dimensional model that simulated cells with changing morphology as circles with oscillating radii and showed that, at intermediate spatial densities, the immune response was maximized at certain oscillation frequencies (the immune response quantified by the likelihood of the interaction between T-cells (shown in blue) and the intruder cell (shown in green).

In this project, we plan to consider a similar model in both two and three physical dimensions and use Topological Data Analysis (TDA) to explain and characterize its physical behavior. Preliminary results show that static TDA measures let us correlate certain topological features with immune response and explain cell dynamics in terms of the system's topology and intercellular forces. Further work will also consider dynamical topological measures, which we expect to be even more insightful regarding the connection between cell dynamics and immune response.

The project will be carried out with Prof. Daniel Parisi, Technical Institute of Buenos Aires, Argentina.

