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*Conditioning and equivariance in a contact detection problem*

In several areas of physical science and engineering involving systems of hard or elastic objects, an essential computational task is to detect contacts and to compute contact forces between objects that are in contact. This is generally done in simulations, for instance via the Discrete Element Method, by allowing the objects to overlap slightly and then computing the elastic force from the overlap distance.

However, given two objects parametrized by relative position, orientation, and relevant shape parameters, the problem of computing the signed distance between them is generally ill-conditioned, and a closed form is unavailable for all but the simplest object geometries. The problem is surprisingly subtle even for ellipses in the plane, creating a nontrivial computational bottleneck for high-precision simulations.

We will discuss ongoing computational and theoretical investigations into this problem from the perspective of equivariant machine learning, focusing on fundamental issues in the application of neural networks to this kind of ill-conditioned problem.