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Deep Reinforcement Learning for Fano Hypersurfaces

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In this talk, we show how deep reinforcement learning can be used to overcome the computational challenges faced by conventional search algorithms in the discovery of new Fano hypersurfaces.

By the Minimal Model Program, varieties can be reduced to three building blocks: Fano, Calabi-Yau, and general type varieties. The building blocks have singular points, which have a property known as terminality. By a result of Birkar there are only finitely many Fano varieties with terminal singularities per dimension, and so one can construct 'periodic tables'. Tables are complete in dimensions 1, 2 and partially in 3. Little is known in dimension 4.

My work aims to classify terminal Fano 4-fold hypersurfaces. There are two obstacles, however; determining terminality is difficult and computationally expensive, and the occurrence of terminal examples is sparse in a vast search space. Together, this makes the discovery of new examples difficult.

I will discuss how creating a deep reinforcement learning search architecture allowed me to find 70,000 examples in under an hour from the 10,000 I was able to produce in days using conventional methods. Interestingly, from nearly all of the examples we have discovered so far, we are able to construct associated nontoric Calabi-Yau 3-fold hypersurfaces with canonical singularities. Their ambient weighted projective spaces are nonreflexive polytopes, and thus are not necessarily in the famous Kreuzer-Skarke list of 473,800,776.

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