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Intelligent Autonomous Machines

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Over two thousand years ago, in his work '*The Politics*', Aristotle imagined creating autonomous instruments:

'*We can imagine a situation in which each instrument could do its own work, at the word of command or by intelligent anticipation...*'

With the robot population currently estimated to be 4.5 million, we are now at the point in history where this long-awaited dream is becoming reality. Advances in machine learning technology have resulted in extremely successful autonomous science missions, such as the seven robotic missions currently operating in orbit or on the surface of Mars, which include the Mars Exploration Rovers: Spirit and Opportunity.

The application of Bayesian methods to machines that interact with the real world faces challenges not encountered in off-line data analysis. Autonomous machines must collect and analyze data on a continual and sequential basis with models sufficiently simple to facilitate efficient computation, while sufficiently robust to result in accurate inferences and decision-making. Moreover, such machines must not only make inferences, but must decide for themselves which measurements to take, which is the basis of experimental design.

I will demonstrate a Bayesian machine that locates and characterizes shapes on a playing field. The intelligent aspects of this machine rely on two systems: an inference engine and an inquiry engine. The inference engine simultaneously performs Bayesian model estimation and Bayesian parameter estimation by relying on the nested sampling algorithm. Meanwhile the inquiry engine performs experimental design by identifying the most relevant measurement given the current state of knowledge of the machine. This is accomplished by computing the relevance of each potential experimental question, which is quantified by the entropy of the possible experimental outcomes. Altogether, this research represents a real-time implementation of a unified framework of both inference and inquiry.