Bayesian Object Detection in Astrophysics

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Detecting objects from noisy data-sets is common practice in astrophysics. Object detection presents a particular challenge in terms of statistical inference, not only because of its multi-modal nature but also because it combines both the parameter estimation (for characterizing objects) and model selection problems (in order to quantify the detection). Bayesian inference provides a mathematically rigorous solution to this problem by calculating marginal posterior probabilities of models with different number of objects, but the use of this method in astrophysics has been hampered by the computational cost of evaluating the Bayesian evidence. Nonetheless, Bayesian model selection has the potential to improve the interpretation of existing observational data. In this work we discuss several Bayesian approaches to object detection problems and describe how the statistical inference on them can be done in an efficient and robust manner. We also describe some recent applications of Bayesian object detection to problems like galaxy cluster extraction, gravitational wave modelling and extra-solar planet detection. These approaches are generic in nature and may therefore be applied beyond astrophysics.

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