University of Glasgow | School of Physics & Astronomy

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Dear Editor,

Gravitational wave detection is now so frequent it is easy to forget that the field is still in its infancy. The most important technical challenges associated with "detection" are mostly solved but those regarding the estimation of parameters are not. In the accompanying letter we describe a new machine learning approach to gravitational wave parameter estimation. We directly compare the performance of this new approach to that of existing Bayesian methods and are able to show that it not only reproduces the optimal Bayesian results, it can do so ~6 orders of magnitude faster.

The speed that gravitational wave data can be processed to obtain accurate estimates of source parameters is a key issue. This task is at the core of multi-messenger observations that aim to observe both the gravitational wave and the electromagnetic emission (or neutrino flux) from common events. The swiftness with which gravitational wave events can be localised on sky is currently O(1) min and this speed is crucial for rapid follow-up with electromagnetic telescopes. Unfortunately, this level of latency still represents a bottleneck in the procedure that limits follow-up observations seeing the most prompt electromagnetic emission.

The complete Bayesian analyses are significantly more computationally costly and for the current LIGO O3 run have taken between 6 hours and 5 days per event. As the sensitivity of the advanced generation detectors improves we will see a dramatic rise in the number of detections and therefore an increased computational cost. This increase is dwarfed by the equivalent rise in detections for the proposed 3rd generation detectors where with current approaches, the detection rate will far exceed the rate at which the signals can be analysed.

The future of gravitational wave astronomy is very bright and we believe that to realise this future we will almost certainly have to depend upon the increasingly exciting field of machine learning. Today's cutting-edge machine learning algorithms need to be able to replicate and exceed the performance of existing methods. We are therefore pleased to submit our original research on the topic of Bayesian parameter estimation using conditional variational autoencoders for gravitational-wave astronomy. Our primary result is that our trained neural network can produce the correct Bayesian posterior distributions on gravitational wave parameters almost instantaneously.

We hope that you would consider this for publication in Nature Physics Letters.

Yours sincerely,

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