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Cosmological constraints from HSC survey first-year data using deep learning

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We present cosmological constraints from the Subaru Hyper Suprime-Cam (HSC) first-year weak lensing shear catalogue using convolutional neural networks (CNNs) and conventional summary statistics. We crop 19 $3 \times 3\mathrm{deg}^2$ sub-fields from the first-year area, divide the galaxies with redshift $0.3 < z < 1.5$ into four equally-spaced redshift bins, and perform tomographic analyses. We develop a pipeline to generate simulated convergence maps from cosmological N-body simulations, where we account for effects such as intrinsic alignments (IAs), baryons, photometric redshift errors, and point spread function errors, to match characteristics of the real catalogue. We train CNNs that can predict the underlying parameters from the simulated maps, and we use them to construct likelihood functions for Bayesian analyses. In the Λ cold dark matter model with two free cosmological parameters Ω and σ_8, we find $\Omega = 0.278^{+0.037}_{-0.035}$, $S_8 \equiv (\Omega/0.3)^{0.5}\sigma_8 = 0.793^{+0.017}_{-0.018}$, and the IA amplitude $A_{\mathrm{IA}} = 0.20^{+0.55}_{-0.58}$. In a model with four additional free baryonic parameters, we find $\Omega = 0.268^{+0.040}_{-0.036}$, $S_8 = 0.819^{+0.034}_{-0.024}$, and $A_{\mathrm{IA}} = -0.16^{+0.59}_{-0.58}$, with the baryonic parameters not being well-constrained. We also find that statistical uncertainties of the parameters by the CNNs are smaller than those from the power spectrum (5-24 percent smaller for S_8 and a factor of 2.5-3.0 smaller for Ω), showing the effectiveness of CNNs for uncovering additional cosmological information from the HSC data. With baryons, the S_8 discrepancy between HSC first-year data and Planck 2018 is reduced from $\sim 2.2\,\sigma$ to $0.3 - 0.5\,\sigma$.

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