Abstract. For a given positive measure μ on $\mathbb{R}^n$, we consider integral functionals of the kind

$$F(u) = \int_{\mathbb{R}^n} f(x, \nabla u, \nabla^2 u)\, d\mu \ , \qquad u \in \mathcal{C}_0^\infty(\mathbb{R}^n) \ ,$$

and we study their relaxation with respect to the L^p_μ topology, being p the growth exponent of f. To obtain the relaxed energy $\overline{F}$, we develop a suitable theory of second order μ-intrinsic operators, related to a Cosserat vector field and to a curvature tensor. Our main theorem shows that the functional $\overline{F}$ is in general a non-local one; this unexpected feature occurs even in very simple examples, when μ is the one-dimensional Hausdorff measure over a closed Lipschitz curve in the plane.