Compressive sensing (CS) is a recently emerging technique and an extensively studied problem in signal and image processing, which suggests a new framework for the simultaneous sampling and compression of sparse or compressible signals at a rate significantly below the Nyquist rate. Maybe, designing an effective regularization term reflecting the image sparse prior information plays a critical role in CS image restoration. Recently, both local smoothness and nonlocal self-similarity have led to superior sparsity prior for CS image restoration. In this paper, first, an adaptive curvelet thresholding criterion is developed, trying to adaptively remove the perturbations appeared in recovered images during CS recovery process, imposing sparsity. Furthermore, a new sparsity measure called joint adaptive sparsity regularization (JASR) is established, which enforces both local sparsity and nonlocal 3-D sparsity in transform domain, simultaneously. Then, a novel technique for high-fidelity CS image recovery via JASR is proposed-CS-JASR. To efficiently solve the proposed corresponding optimization problem, we employ the split Bregman iterations. Extensive experimental results are reported to attest the adequacy and effectiveness of the proposed method comparing with the current state-of-the-art methods in CS image restoration.