An accurate wrench model is significant for the simulation, manufacture, and control of the commutated magnetically levitated planar actuator (CMLPA). With plenty of coils and permanent magnets employed in the coil set and magnet array of CMLPA, the computational burden of the corresponding wrench model can be substantial. This paper proposes an accurate, universal, and robust parallel massive-thread wrench model (PMWM) for the CMLPA. In PMWM, the magnetic node, Gaussian quadrature, and coordinate transformation are employed to express the interaction between magnet array and coil set. All of these calculation modules are implemented on the graphics processing unit in a massively parallel framework by CUDA. In order to highlight the performance of this PMWM, the wrench model of three different CMLPAs is computed. The computation accuracy and efficiency of proposed PMWM are compared with the finite-element method software Ansys Maxwell and a boundary element method software package named Radia, respectively. The same wrench model is also implemented on a multicore CPU through OpenMP and the comparative results are presented to show significant acceleration of the proposed massive-thread model.