This paper considers data-based real-time adaptive Fault Detection (FD) in Grid-connected PV (GPV) systems under Power Point Tracking (PPT) modes during large variations. Faults under PPT modes remain undetected for longer periods introducing new protection challenges and threats to the system. An intelligent FD algorithm is developed through real-time multi-sensor measurements and virtual estimations from Micro Phasor Measurement Unit (Micro-PMU). The high-dimensional high-frequency multivariate characteristics are nonlinear time-varying where computational efficiency becomes crucial to realize online adaptive FD. The adaptive assumption-free method is developed through Principal Component Analysis (PCA) for dimension reduction and feature extraction with reduced complexity. Novel fault indicators Dx(t) and discrimination index AD(t) are developed using Kullback–Leibler Divergence (KLD) for an accurate evaluation of Transformed Components (TCs) through recursive Smooth Kernel Density Estimation (KDE). The algorithm is developed through extensive data with 2.2×106 measurements from a GPV system under Maximum PPT (MPPT) and Intermediate PPT (IPPT) switching modes. The validation scenarios include seven faults: open circuit, voltage sags, partial shading, inverter, current feedback sensor, and MPPT/IPPT controller in boost converter faults. The adaptive algorithm is proved computationally efficient and very accurate for successful FD under large temperature and irradiance variations with noisy measurements