Robots still struggle with everyday manipulation tasks. An overriding problem with robotic manipulation is uncertainty in the robot's state and calibration parameters. Small amounts of uncertainty can lead to complete task failure. This thesis explores ways of tracking and calibrating noisy robot arms using computer vision, with an aim toward making them more robust. We consider three systems with increasing complexity: a noisy robot arm tracked by an external depth camera, a noisy arm that localizes itself using a hand-mounted depth sensor looking at an unstructured word, and a noisy arm that only has a single hand-mounted monocular RGB camera estimating its state while simultaneously calibrating its camera extrinsics. Using techniques taken from dense object tracking, fully dense SLAM and sparse general SLAM, we are able to automatically track the robot and extract its calibration parameters. We also provide analysis linking these problems together, while exploring the fundamental limitations of SLAM-based approaches for calibrating robot arms.