Acoustic-to-articulatory inversion, the determination of articulatory parameters from acoustic signals, is a difficult but important problem for many speech processing applications, such as automatic speech recognition (ASR) and computer aided pronunciation training (CAPT). In recent years, several approaches have been successfully implemented for speaker dependent models with parallel acoustic and kinematic training data. However, in many practical applications inversion is needed for new speakers for whom no articulatory data is available. In order to address this problem, this dissertation introduces a novel speaker adaptation approach called Parallel Reference Speaker Weighting (PRSW), based on parallel acoustic and articulatory Hidden Markov Models (HMM). This approach uses a robust normalized articulatory working space and palate referenced articulatory features combined with speaker-weighted adaptation to form an inversion mapping for new speakers that can accurately estimate articulatory trajectories. The proposed PRSW method is evaluated on the newly collected Marquette electromagnetic articulography (EMA) – Mandarin Accented English (MAE) corpus using 20 native English speakers. Cross-speaker inversion results show that given a good selection of reference speakers with consistent acoustic and articulatory patterns, the PRSW approach gives good speaker independent inversion performance even without kinematic training data.