DISTRIBUTED LOCALIZATION OF CAMERA NETWORKS

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ABSTRACT

Motivated by applications in ad-hoc camera networks, we present distributed algorithms for the automatic, external, consistent, metric calibration of a network of cameras distributed over a large geographical area with no centralized processor. First, we model the set of uncalibrated cameras as nodes in a communication network, and propose a distributed algorithm in which each camera only communicates with other cameras that image some of the same scene points. For this algorithm, we analyze the number and distribution of messages sent along one-hop communication links, and show that the distributed algorithm results in a fairer allocation of messages per link compared to a centralized algorithm. We also discuss how to obtain accurate and globally consistent self-calibration of a distributed camera network based on a message passing algorithm. The natural geometry of the system and the formulation of the estimation problem give rise to statistical dependencies that can be efficiently leveraged in a belief propagation (BP) framework. The problem differs from typical BP applications in computer vision in that joint estimates of tens of continuous parameters are propagated around the network. Furthermore, the camera calibration problem poses additional challenges to information fusion, including overdetermined parameterizations and non-aligned coordinate systems. We suggest practical approaches to overcome these difficulties and demonstrate the performance our algorithms based on both real and simulated networks. We also demonstrate how the calibrated network can locally collaborate to estimate the shape of objects moving through the field of cameras.In the final part of the thesis, we investigate extensions and approximations to the BP algorithm for improving speed and accuracy for noise standard deviations up to 2 pixels. We also use Monte Carlo analysis to investigate the true nature of probability densities representing the uncertainties in a typical structure-from-motion scenario.