

Global Estimation with Local Communication*

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{ittay@tx, idish@ee, stacyp@ee, rom@ee}.technion.ac.il**Abstract**

We present a distributed optimization algorithm for estimating a continuous function such as temperature or pollution over a geographic region, e.g., a road network. The estimate is generated from samples taken by sensors placed alongside roads or in cars driving along them. We employ piecewise estimation, that is, we divide the region into sectors and find an estimate for each sector, e.g., a polynomial or a line, so that their union is a continuous function that minimizes some global error function. The computation is distributed by designating a node (either virtual or physical) that is responsible for estimating the function in each sector. The estimate is then computed based on the samples taken in the sector and information from adjacent nodes.

The algorithm works in networks with bounded, yet unknown, latencies. It accommodates dynamic inputs (samples) and node arrivals and departures. Our algorithm converges to the global optimum with only local communication, using a novel, distributed implementation of coordinate ascent optimization.

1 Introduction

As we enter the era of ubiquitous sensing, we are able to monitor the environment with unprecedented resolution using large scale *sensor networks*. Each sensor measures some phenomenon, and communicates wirelessly with its neighbors.

To cope with vast amounts of data collected in a wide geographical area, we need to summarize it. However, it is infeasible to collect and analyze all the information at a central location [4]. Although sensors may be equipped with cellular and long distance communication modules, these are both expensive and energy intensive.

Moreover, forwarding all samples to a central location is impractical due to the large number of messages and the heavy load on nodes close to the center. These restrictions indicate a need for a distributed solution where the summary of the sensed data is generated within the network.

We propose a novel *distributed* approach for generating a compact estimate of a continuous physical phenomenon from *samples* measured throughout a region. Our solution is *selective* — each participant only learns of the estimate in its vicinity. We seek to estimate the phenomenon by a continuous function that is optimal in some sense with respect to the samples. Our approach is to divide the region into *sectors* and to obtain an estimate for each sector such that the union of these estimates is continuous over the region. Each sector is assigned a *node*, which may be either a physical station or a virtual node [9, 5, 7]. The division of the region and assignment of nodes can be done with known techniques [9, 5, 7, 14] and is outside the scope of this paper.

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