Performance Analysis of a Multi Window Stereo Algorithm on Small Scale Distributed Systems: A Message Passing Environment

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Abstract. Stereo vision systems determine the depth from two or more images which are taken at the same time, but from slightly different viewpoints. A novel approach for depth map generation is proposed for a multi-window stereo algorithm on a cluster computing setup using Message Passing Instructions (MPI) to overcome the speed limitations.

Keywords: Stereo vision, Depth map, Symmetric stereo with Multiple Windowing algorithm, Parallel Depth map Generation, Cluster computing setup, Message Passing Instructions.

1 Introduction

Stereo vision refers to the process, which transforms the information of two plane images (2-D) into a description of the 3D scene and recovers depth information in terms of exact distance (Depth map). The Stereo vision in mobile Robot is attained by equipping the Robot with two stereo cameras similar to Human Visual System (HVS). To overcome the speed limitations of vision-based algorithms several hardware software implementations were presented[2][3][4][5][6]. The existing hardware architectures are difficult to implement in real-life environment and not suitable low cost commercial applications due to their high equipment cost and complex configurations. In this work, a novel method for depth map generation is presented for an existing state of the art algorithm SMW[1] to overcome its speed limitations.

2 Depth Map Generation: A Parallel Implementation

The sequential SMW(Symmetric Stereo With Multiple Windowing) algorithm is adaptive and uses multiple windowing approach. For each pixel a correlation is performed with nine different windows. The SMW algorithm has the computational complexity of $O(n^2)$.

V.V. Das, G. Thomas, and F. Lumban Gaol (Eds.): AIM 2011, CCIS 147, pp. 340–343, 2011.

2.1 Parallel SMW Algorithm

The parallel algorithm is designed to work with a cluster of computers connected in parallel. Each node in the cluster processes a part of the left-right image pair to generate partial depth map. The server receives the sensor data of right and left images. The received data is divided into equal number of segments which is equal to the number of processors in the cluster (Fig. 1) including the server. Each slave processor has the copy of SMW algorithm implementation. The server sends each pair of image segments to a unique processor in the cluster. Each processor executes SMW algorithm and calculates the partial depth map to each image segment. Partial depth maps are sent to the server and are combined to form the complete depth map of the image pair.

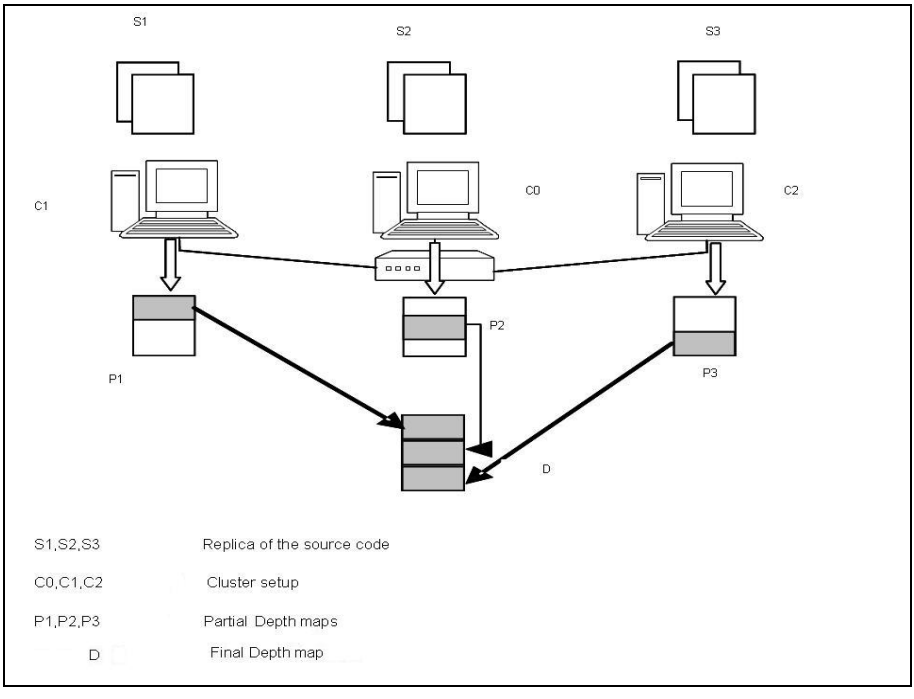

Fig. 1. Cluster computing setup for depth map generation

3 Analysis of the Algorithm

Based on the Amdahl's law analysis, the speedup achievable by parallel SMW algorithm for a fixed size problem increases initially with the increase in the number of processors and becomes stable (Fig. 2). As the number of processors increases, the parallel overhead increases which reduces the overall performance of the algorithm.

The expected execution time is given by

$$[m^2/p + n[\log p]\lambda + [\log p](k/\beta)] . \quad (1)$$

Where λ (latency) represent the time needed to initiate a message. β (bandwidth) represent the number of data items that can be sent down a channel in one unit of time. k indicates the data items. n indicates the message length.

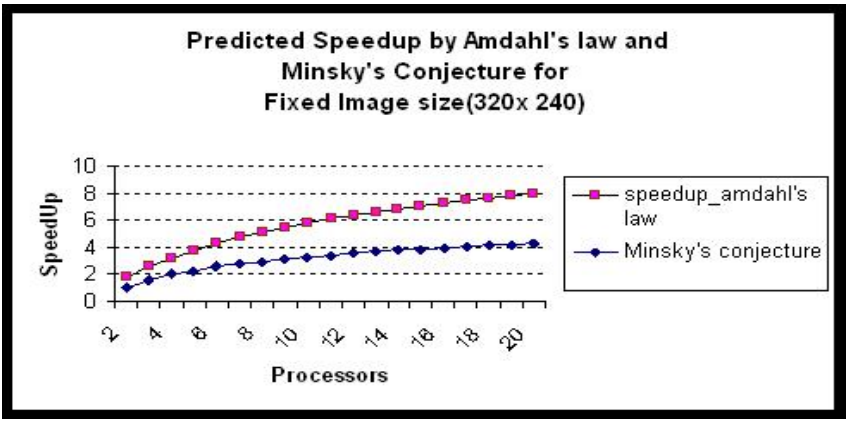

Fig. 2. Predicted speedup of depth map generation

The algorithm is tested for various synthetic and real life stereo images (Fig 3) and a speedup in the band from 1.48 to 1.68 and efficiency from 0.74 to 0.84 on two node cluster. By adding one more node i.e. on three node cluster, speedup varied in the band from 2.28 to 2.58 and efficiency from 0.77 to 0.86. Based on the results it can concluded that the SMW algorithm can be implemented in parallel to improve speedup, yet the practical speedup is less than the speedup predicted by Amdahl's law.

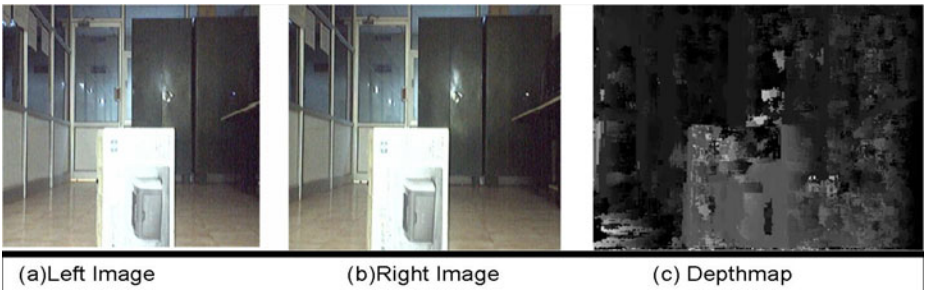

Fig. 3. Depth map creation using stereo vision

4 Conclusion

A parallel multi-window stereo algorithm (SMW) for the depth map generation, on cluster computing setup is developed to overcome the slow response time of the existing multi-window algorithms. Based on the results it can be concluded that the

performance of the algorithm initially improves with increase in number of processors but the observed improvement is less than the improvement expected by the Amdahl's law in the cluster computing environment.

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