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Editor's Foreword
Special Issue on Parallel Algorithms for Geometric Problems on Digitized Pictures

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Image processing is one of the major fields of application for parallel processing. Some of the first multiprocessors were mainly built for processing images (e.g., the MPP for analyzing LANDSAT satellite data) because for such applications data volumes are often so large that the use of standard sequential machines becomes impracticable. In addition to standard image processing operations such as noise removal, edge detection, filtering, etc., researchers have recently also started to study other "high-level" geometric operations which are well known in *computational geometry*. This special issue of *Algorithmica* is devoted to parallel algorithms for computational-geometry problems on digitized pictures. The motivation for studying such operations is that in practice geometric data for computational-geometry applications is often given in the form of an image; hence, parallel algorithms which can be applied directly to the image may be more efficient than applying "standard" parallel computational-geometry methods which require that the image is first converted into, e.g., a set of polygonal chains.

For example, consider the standard *path-planning* problem in robotics: given a set of simple polygons in the plane representing the obstacles and a polygon representing the robot, find the shortest path for the robot to move from point A to point B without colliding with any obstacle. In practice, the robot might be moving in a factory hall; instead of first creating a polygonal description of the obstacles and the robot, it may be more efficient to use as input an *image* obtained from a camera mounted to the ceiling of the factory. Using an image from a camera might also be more practical for dynamic environments where the locations and shapes of the obstacles are changing. Since the factory, and thus the image of the obstacles, could be very large and the robot's path has to be determined in real-time, a *parallel* method for solving the path-planning problem directly on the image is desirable.[2]

When solving computational-geometry problems for images in parallel, researchers have several different types of parallel machines available. The papers selected for this special issue consider four very commonly used ones: the parallel

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[2] For an image with n pixels stored in a $\sqrt{n} \times \sqrt{n}$ mesh-of-processors, an $O(\sqrt{n})$-time algorithm is described in F. Dehne, A.-L. Hassenklover, and J.-R. Sack, "Computing the configuration space for a robot on a mesh-of-processors", *Parallel Computing*, Vol. 12, 1989, pp. 221–231.

random access machine (PRAM), the pyramid computer, the mesh-of-trees, and the mesh-of-processors.

D. Moitra considers the PRAM model and studies a problem arising, e.g., in the compact encoding of a VLSI design: finding a minimal set of (possibly overlapping) maximal squares covering a given image. A major contribution of this paper is the introduction of a new data structure, the cover graph, which can be utilized to represent efficiently the covering relationship between the maximal squares of an image.

R. Miller and Q. F. Stout study, for the pyramid computer, problems involving convexity properties of images consisting of a single or multiple figures. They present algorithms for enumerating the extreme points of (convex and nonconvex) sets and for deciding the convexity of each figure in an image. They also describe algorithms for deciding linear separability of two figures, determining the diameter (for any l_p metric) and the smallest enclosing rectangle of each figure, and for determining whether a set of pixels could have arisen from the digitization of a straight line segment.

O. Schwarzkopf considers the problem of computing the distance transform: for a set of black pixels, compute for every pixel its distance to the closest black pixel. This problem, which can be seen as the digitized version of Voronoi diagram construction, is studied for the pyramid computer and mesh-of-trees.

H. M. Alnuweiri and V. K. Prasanna Kumar consider an extended version of the mesh-of-processors, called mesh-connected modules: n^2 memory modules are arranged on a grid and subdivided into k^2 subgrids where each subgrid has n/k processors attached to the diagonal memory modules, and each processor is connected by a bus to all memory modules in the same row and column of its subgrid. They present algorithms for histogramming a gray level image (for each gray value, compute its number of occurences), connected component labeling, computing the convex hulls of multiple figures, computing the distance transform for l_1 metric, and computing for each figure its nearest figure.

The final two papers study image processing problems for the standard mesh-of-processors architecture. F. Dehne, A.-L. Hassenklover, J.-R. Sack, and N. Santoro describe algorithms for computing all contours and all rectilinear convex hulls of an image (peeling), solving the parallel, perspective, and rectangular visibility problem for disjoint figures, detecting separability and pseudo star-shapeness, and constructing the digitized Voronoi diagram of disjoint figures (e.g., points, line segments, circles, ellipses, and polygons of constant size) for a large class of distance functions. M. J. Atallah, S. E. Hambrusch, and L. E. TeWinkel present a mesh algorithm for computing a topological numbering of horizontally convex digitized figures. The problem, which arises, e.g., in motion planning, is to assign a number to each figure such that, for every figure, all figures to its left have a smaller number assigned to them.

I hope that this special issue helps to create further interest in this fairly new field of algorithm design. Besides the opportunity to discover new and interesting algorithms, results in this area have many direct practical implications. As indicated above, there are numerous parallel image-processing machines already available and just waiting to be used for more "high-level" computational-geometry applications. Graphics workstations and animation systems are containing increasing amounts of parallel hardware in particular in their image-processing part. Some have special purpose hardware for overlaying and combining images or, e.g., special purpose processors attached to subgrids of the image for operations like scaling, translation, or rotation. These enhancements are so far mainly used for speeding up the graphics primitives of the respective system, but high-level parallel image-processing operations such as the ones described in this special issue can obviously also lead to further performance improvements.

It has been a very enjoyable and satisfying experience for me to edit this special issue, and I would like to thank all the authors who submitted papers and all the referees who helped evaluating the submissions.