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Editorial

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Editorial

Three-dimensional (3D) scanning and geometric processing of scanned data are two companioning technologies in 3D digitization, with one acquiring 3D points from physical objects and the other processing the acquired data points into digital geometric models for subsequent uses. These two techniques are increasingly being adopted in a variety of product development processes such as reverse engineering and quality inspection in aerospace, automotive, die and mold, biomedical, consumer products, mass customization, and many other applications such as animation and digital archival.

Rapid advancement of 3D scanning techniques and growing use of massive point-cloud data in various 3D applications have spurred extensive research in point-based geometric processing. To support these vast point-based applications, computational techniques drawing concepts and knowledge from applied mathematics, computer science, and engineering are developed for acquiring, processing and simulating complex point-based 3D models.

Arguably, such point-based computational techniques need to address the issues of surface representation, computational performance and application opportunities, and to provide answers to many inter-related research questions, such as: What surface representations can enable better geometric computing with broad applicability in various point-based applications? Which are the best algorithms for handling and processing large amount of point-cloud data efficiently and accurately, how can their robustness to noise and outliers be increased, and how can their computational performance be optimized? Will the progress in surface representation and computational performance research lead to new applications? Do new research issues in surface representation and algorithmic performance emerge as a result of the applications?

This special issue provides a good sample of research progress in the above three areas. On the one hand, we are witnessing that different surface representations such as implicit surfaces, parametric surfaces, and polygonal meshes are being used in various applications. On the other hand, we are observing that algorithms that can extract surface information, such as curvatures and principal axes, directly from points without surface reconstruction are being developed. More specifically, this issue consists of papers addressing data registration accuracy and outlier removal, implicit surfaces and statistical approaches based geometric computing, and meshless physical simulation, and a 3D scanning application in dental crown restoration.

Data acquired by laser scanners at different view orientations or by different sensors need to be registered into one common coordinate system. Two papers in this special issue extend the state-of-the-art in multi-view and multi-sensor data registration. The paper by Kim *et al* presents a method for simultaneous registration of multiple range views via markers where a hybrid metric function consisting of tangent distance error and normal distance penalty of markers is minimized. In the paper by Huang, Qian and Chen, a multi-sensor calibration approach, called iterative registration and fusion, is presented. The key idea of this approach is to use surfaces reconstructed from multiple point clouds

to enhance the registration accuracy and robustness. It iteratively registers the discrete 3D sensor data against an evolving reconstructed B-spline surface, which results from the Kalman filter-based multi-sensor data fusion.

Scanned data sometimes contains measurement outliers due to factors such as sensor noise and inter-reflection (sometimes a.k.a double bounce) of laser light. Automatic removal of outliers is desired in many point-based applications. In the paper by Shen et al, an approach for separating non-isolated outliers (i.e. outliers close to a main surface) is proposed. It integrates surface propagation with a minimum variance principle and recursive Bi-clustering algorithm to form a coherent approach for detecting non-isolated outlier clusters.

The surface models underpinning point-based geometric computing are frequently based on implicit modeling techniques. In the paper by Liu and Wang, an approach, termed duplex-fitting, is presented to model both the zero-level surface and its offset surfaces with a single implicit function. The implicit function is based on compactly supported radial basis function (CSRBF). The CSRBF reconstructed from the hierarchical approach interpolates or approximates simultaneously the zero-level surface and the offset surface of a given point set.

This special issue also features two papers on robust statistical techniques that can extract intrinsic surface properties such as line of curvatures and principal axes. In the paper by Kalogerakis et al, a robust statistical approach for extracting lines of curvature from point clouds is presented. This statistical approach acquires maximum likelihood estimates of curvature through an iterative re-weighted least squares method. In the paper by Liu and Ramani, a robust technique for determining the principal axes of a point set is presented. It uses least median of squares for outlier detection and uses techniques from robust statistics to guide principal component analysis.

Besides geometric computing, point-based computational techniques are also used in mesh-less simulation of physical phenomena. In the paper by Paiva et al, point-based computational techniques are extended to simulations of visco-plastic effects of solid materials, e.g. plastic, wax and clay. The authors propose to model a solid object through a non-Newntonian fluid with high viscosity. The fluid simulation is based on a smoothed particle hydrodynamics method and the viscosity based on a general Newtonian fluid model. Effects such as creep, melting, hardening and flowing are demonstrated.

The last paper in this issue is by Fang and Kuo and it focuses on practical application of point-cloud data acquisition and processing in dental applications. It uses an optical tracking device to obtain discrete points from opposing teeth during the chewing movement, and uses the extracted coupler points to reconstruct the occlusal surface, a surface that occludes with and contacts an opposing tooth surface. It provides an accurate surface model for custom teeth fabrication and can avoid/reduce denture reshaping in clinic.

The eight papers contained in this special issue do not cover all aspects of point-based computational techniques, but they are representative examples of recent progress in this area and give us an indication where the research is going. We anticipate, in conjunction with work reported in this special issue, research in algorithms for exploiting multi-core processors and graphics processing units to improve the algorithmic efficiency, and research in representations such as point-sampled surface that define surfaces directly from points hold great promise in the future.

It has been our great pleasure to contribute as guest editors to this special issue. We thank the reviewers for their meticulous and timely feedback, and the authors for submitting their research results without which this issue would not be possible. Some papers submitted to this special issue will be published in regular issues due to the space limitation. We hope that this compilation of papers will be useful for you and that you will enjoy reading this special issue.

Guest-editors:
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