RESEARCH STATEMENT
Edmond J. Nadler

My primary research area is Computer Aided Geometric Design (CAGD), which can be defined as the representation and approximation of geometric entities, mainly curves and surfaces, for use on the computer, for example, in CAD systems. This applicable area combines my lifelong interests in applied mathematics, geometry and computing. Since completing my Ph.D. in applied mathematics, I have worked both in academia and industry, and this has naturally influenced the course of the research.

For the first eight years after my Ph.D., while in academia, my research focused on three topics: triangulations, bivariate splines, and shape-preserving interpolation. My thesis [1985, 1986] and subsequent related research [1989, 2007b] concerned optimal triangulation for approximating a scalar function of two variables by a piecewise linear function defined over the triangulation, and has been frequently cited as important work in the field.

In the work on bivariate splines, the focus was on the dimension of spaces of piecewise polynomial spaces and the related ability of such functions to interpolate given types of data. For example, the dimension of the space of $C^1$ piecewise quartic polynomials defined on a triangulation expressed in terms of the numbers of vertices, edges and faces of the triangulation suggests that it is always possible to interpolate function values and gradients given at the vertices of the triangulation by a function in this space [1987]. I constructed this interpolant for all but a very special class of triangulation [1990].

In the area of shape-preserving interpolation, I considered construction of interpolating curves or surfaces that preserve the positivity, monotonicity or convexity of point data. For example, I defined general notions of monotonicity for bivariate functions [1992a]; developed and proved necessary and sufficient conditions for the positivity of a quadratic function defined on a triangle [1992b], and used this to construct an algorithm for positivity-preserving interpolation by bivariate quadratic splines; and developed with D. Levin a scheme for convexity-preserving interpolation by algebraic curves, with a generalization to surfaces [1995a].

During the subsequent eight years in industry, my research focus shifted to designing and developing practical algorithms for surface construction mainly using NURBS surfaces. Drawing upon the expertise in CAGD gained through the prior years of academic research, I made important contributions to the geometry software of three companies. The projects included algorithms for the construction of high quality loft, sweep, fillet, blend, and $n$-sided patch surfaces [1995b], and the efficient computation of distances of a cloud of points to a collection of trimmed NURBS surfaces. In each case, the algorithms improved upon existing methods in the literature.

In industry, I came up with ideas for CAGD problems both useful and mathematically interesting, and insight into what makes a problem so. As I return to academic research, I am using this perspective, presented in [2003a, 2003b], to help select research problems. And the computing skills honed during my years in industry will help in solving these problems.

One example of such a problem that I have been studying is the following: Generalize known techniques for parameterizing a sequence of points for curve fitting, to the case where derivative data is given at some of the points. This problem arose in industry, where I was able to work out a solution that served the purpose. More recently, I came up with a better approach, which I presented in [2005].

Another insight I gained in industry is that a large class of curve and surface fitting problems can and should be unified under a single framework. As a longer-term research goal, I plan to work out such a framework.

Another direction for my research is in the widely applicable area of Virtual Reality, in which CAGD, also known as Geometric Modeling, plays a key role. As a faculty advisor for three semesters at a course in this field, I have learned much about the field while advising students with projects, and have been exposed to a wide variety of potential research topics. A student term project I supervised in the Fall 2006 term involved the creation of an interactive NURBS tutorial in Virtual Reality [2006a, 2006b], and this work may be continued.

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Yet another direction for my research is in Compressed Sensing, a hot research topic with roots in several fields, including that of my original research field of Approximation Theory. I attended a (invitation only) 2-week workshop on this at the IMA in summer 2007, taught by top experts in the field. The group project in which I participated was in the application of Compressed Sensing to MRI [2007a].

Finally, I have also turned my attention back to the topic of my thesis, mentioned above, and produced some new results which I presented in an invited talk [2007b] at a leading international CAGD conference.

REFERENCES for RESEARCH STATEMENT
Selected Publications and Presentations by E.J. Nadler


