7
Conclusions

The computation of truly fair curves and surfaces has been difficult due to poor fairness measures and lack of computational resources. In this thesis we have described new fairness measures and computational techniques that produce curves and surfaces of very clearly superior quality. Our fairness measures are based on minimizing the variation of curvature. Curves and surfaces are computed using numerical optimization techniques that were, until recently, too computationally intensive to be practical for general use. The continuing increases in and wide availability of processing power are making these techniques both practical and attractive.

Our work in this area is only a start. There are many problems that are too large to be solved in a practical amount of time. Although the curve optimization techniques are fast enough to support truly interactive design, surface computation is far too time consuming. This slowness is ameliorated by the fact that, for most design problems, minimum variation surfaces behave in a predictable manner and produce superior shapes. This behavior reduces the number of iterations required in the design process.

There are several areas of research that need development. First, the functionals we have described must be numerically integrated. We have seen that it is this integration step that dominates the time to compute MVC and MVS. Research into good linear approximations of the minimum variation functionals should dramatically reduce computation times. Another aspect of our research is that we have defined a new class of curves (MVC & SI-MVC) and surfaces (MVS & SI-MVS) that warrant a more thorough investigation of their properties. Minimum variation curves and surfaces are still largely unknown. We only have experience with them relative to shape design. It will be interesting to explore the properties of these curved forms and their scale independent relatives.

The increasing power of computers and their growing availability continues to expand the number of problems and approaches that were once intractable and impractical that are

now workable. In our work, the use of computationally intensive optimization techniques has greatly simplified some of the basic problems of surface design and freed us to focus on the actual problem of designing shapes.

Bibliography

1. *Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables*, ed. M. Abramowitz and I. A. Stegun, 887-888. Dover Publications, Inc., New York, 1972.
2. T. G. Ackland. "On Osculatory Interpolation, where the given values of the function are at unequal intervals." *Journal of the Institute of Actuaries*, 49 (1915): 369-375.
3. J. Alan Adams. "The Intrinsic Method for Curve Definition." *Computer Aided Design*, 7 (October 1975): 243-249.
4. Hiroshi Akima. "A New Method of Interpolation and Smooth Curve Fitting Based on local Procedures." *Journal of the Association for Computing Machinery*, 17 (October 1970): 589-602.
5. Bengt Asker. "The Spline Curve, A Smooth Interpolating Function used in Numerical Design of Ship-Lines." *BIT*, 2 (1962): 76-82.
6. A. A. Ball and D. J. T. Storry. "Conditions for Tangent Plane Continuity over Recursively Generated B-Spline Surfaces." *ACM Transactions on Graphics*, 7 (April 1988): 83-102.
7. A. A. Ball. "A Simple Specification of the Parametric Cubic Segment." *Computer Aided Design*, 10 (May 1978): 181-182.
8. Brian A. Barsky and John C. Beatty. "Local Control of Bias and Tension in Beta-splines." *Computer Graphics* (1983): 193-218.
9. Brian A. Barsky. *Computer Graphics and Geometric Modeling Using Beta-splines.* Springer-Verlag, New York, 1988.
10. James M. Beck, Rida T. Farouki and John K. Hinds. "Surface Analysis Methods." *IEEE Computer Graphics and Applications*, 6 (December 1986): 18-36.
11. Etienne Beeker. "Smoothing of Shapes Designed with Free-Form Surfaces." *Computer-Aided Design*, 18 (1986): 224-232.
12. P. E. Bézier. "Example of an Existing System in the Motor Industry: the Unisurf System." *Proceedings of the Royal Society of London.* Series A. 321 (1971): 207-218.

13. G. Birkhoff and C. R. de Boor. “Piecewise Polynomial Interpolation and Approximation.” In *Approximation of Functions*, ed. H. L. Garabedian, 164-190. Elsevier, New York/Amsterdam, 1965.
14. G. Birkhoff, H. Burchard and D. Thomas. “Nonlinear Interpolation by Splines, Pseudosplines, and Elastica.” Research Publication No. 468, General Motors Research Laboratories, 1965.
15. G. D. Birkhoff. *Aesthetic Measure*. Harvard University Press, Cambridge, MA, 1933.
16. James F. Blinn and Martin E. Newell. “Texture and Reflection in Computer Generated Images.” *Communications of the ACM*, 19 (October 1975): 542-547.
17. Wolfgang Böhm. “On Cyclides in Geometric Modeling.” *Computer Aided Geometric Design*, 7 (1990): 243-255.
18. Wolfgang Böhm, Gerald Farin and Jürgen Kahmann. “A Survey of Curve and Surface Methods in CAGD.” *Computer Aided Geometric Design*, 1 (1984): 1-60.
19. Wolfgang Böhm. “Rational Geometric Splines.” *Computer Aided Geometric Design* (1987): 67-77.
20. Wolfgang Böhm. “On Cubics: A Survey.” *Computer Graphics and Image Processing*, 19 (1982): 201-226.
21. Vincent Braibant, Claude Fleury and Pierre Beckers. “Shape Optimal Design - An Approach Matching CAD and Optimization Concepts.” In *Optimization in Computer-Aided Design*, ed. J. S. Gero, 321-269. North-Holland Publishing Company, 1985.
22. J. A. Brewer and D. C. Anderson. “Visual Interaction with Overhauser curves and surfaces.” *Computer Graphics*, 11 (July 1977): 132-137.
23. K. W. Brodlie. “A Review of Methods for Curve and Function Drawing.” In *Mathematical Methods in Computer Graphics and Design*, ed. K. W. Brodlie, 1-37. Academic Press, 1980.
24. K. W. Brodlie. “Methods for Drawing Curves.” In *Fundamental Algorithms for Computer Graphics*, ed. R. A. Earnshaw, 303-323. Springer-Verlag, 1985.
25. Ingrid Brueckner. “Construction of Bézier Points of Quadrilaterals from Those of Triangles.” *Computer Aided Design*, 12 (1980): 21-24.
26. Pere Brunet. “Including Shape Handles in Recursive Subdivision Surfaces.” *Computer Aided Geometric Design*, 5 (1988): 41-50.
27. Su Bu-Qing and Liu Ding-Yuan. *Computational Geometry, Curve and Surface Modeling*. Academic Press, San Diego, 1989.
28. C. R. Calladine. “Gaussian Curvature and Shell Structures.” *The Mathematics of Surfaces* 179-196 Clarendon Press, Oxford, England, 1986..
29. Edwin Catmull and James H. Clark. “Recursively Generated B-spline Surfaces on Arbitrary Topological Meshes.” *Computer-Aided Design*, 10 (1978): 350-355.
30. Alfred S. Cavaretta and Charles A. Micchelli. “The Design of Curves and Surfaces by Subdivision Algorithms.” In *Mathematical Methods in Computer Aided Geometric Design*, ed. T. Lyche and L. L. Schumaker, 115-153. Academic Press, San Diego, 1989.

31. George Celniker and Dave Gossard. “Deformable Curve and Surface Finite-Elements for Free-Form Shape Design.” *Computer Graphics*, 25 (July 29 - August 2, 1991): 257-266.
32. Peter Charrot and John A. Gregory. “A Pentagonal Surface Patch for Computer Aided Geometry.” *Computer Aided Geometric Design*, 1 (1984): 87-94.
33. Hiroaki Chiyokura and Fumihiko Kimura. “Design of Solids with Free-form Surfaces.” *Computer Graphics*, 17 (July 1983): 289-298.
34. Hiroaki Chiyokura. “Localized Surface Interpolation Method for Irregular Meshes.” In *Advanced Computer Graphics: Proceedings of Computer Graphics Tokyo 86'*, ed. T. L. Kunii, 3-19. Springer-Verlag, New York, New York, 1986
35. Hiroaki Chiyokura, Teiji Takamura, Koichi Konno and Tsuyoshi Harada. “G^1 Surface Interpolation Over Irregular Meshes with Rational Curves.” In *NURBS for Curve and Surface Design*, ed. G. E. Farin, 15-34. Society for Industrial and Applied Mathematics, 1991.
36. Hiroaki Chiyokura. *Solid Modeling with DESIGNBASE*. Addison-Wesley Publishing, 1988.
37. A. K. Cline. “Scalar- and Planar- Valued Curve Fitting Using Splines Under Tension.” *Communications of the ACM*, 17 (April 1974): 218-220.
38. Elaine Cohen. “A New Local Basis for Designing with Tensioned Splines.” *ACM Transactions on Graphics*, 6 (April 1987): 81-122.
39. Samuel Daniel Conte and Carl de Boor. *Elementary Numerical Analysis: An Algorithmic Approach.* 3d ed. McGraw-Hill, New York, 1980.
40. Steven A. Coons. “Surface patches and B-spline Curves.” In *Computer Aided Geometric Design*, ed. R. E. Barnhill and R. F. Riesenfeld, 1-16. Academic Press, Inc., Orlando, Florida, March 18-21, 1974.
41. Courant and Hilbert. *Methods of Mathematical Physics*. Interscience, London, England, 1953.
42. M. G. Cox. “The Numerical Evaluation of B-splines.” National Physical Laboratory Report DNAC 4, August 1971.
43. Carl de Boor. “On Calculating with B-Splines.” *Journal of Approximation Theory*, 6 (1972): 50-62.
44. Carl de Boor, Klaus Höllig and Malcolm Sabin. “High Accuracy Geometric Hermite Interpolation.” *Computer Aided Geometric Design* (1987): 269-378.
45. Paul de Faget de Casteljau. “Outillage Méthodes Calcul.”, André Citroën Automobiles SA, Paris, France, 1959.
46. Wendelin L. F. Degen. “Explicit Continuity Conditions for Adjacent Bézier Surface Patches.” *Computer Aided Geometric Design*, 7 (1990): 181-189.
47. Anthony D. DeRose. “Geometric Continuity: A Parametrization Independent Measure of Continuity for Computer Aided Geometric Design.” Report No. UCB/CSD 86/255, Computer Science Division (EECS), University of California, Berkeley, August 1985.
48. Tony D. DeRose and Brian A. Barsky. “Geometric Continuity, Shape Parameters, and Geometric Constructions for Catmull-Rom Splines.” *ACM Transactions on Graphics*, 7 (January 1988): 1-41.

49. Tony D. DeRose. “Necessary and Sufficient Conditions for Tangent Plane Continuity of Bézier Surfaces.” *Computer Aided Geometric Design*, 7 (1990): 165-179.
50. Tony D. DeRose and Stephen Mann. “An Approximately G^1 Cubic Surface Interpolant.” In *Mathematical Methods in Computer Aided Geometric Design II*, ed. T. Lyche and L. L. Schumaker, 185-196. Academic Press, Inc., San Diego, 1992.
51. John C. Dill. “An Application of Color Graphics to the Display of Surface Curvature.” *Computer Graphics*, 15 (August 1981): 153-161.
52. Manfredo P. Do Carmo. *Differential Geometry of Curves and Surfaces.* Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1976.
53. D. Doo and M. Sabin. “Behavior of Recursive Division Surfaces Near Extraordinary Points.” *Computer-Aided Design*, 10 (1978): 356-360.
54. Nira Dyn, David Levin and Charles A. Micchelli. “Using Parameters to Increase Smoothness of Curves and Surfaces Generated by Subdivision.” *Computer Aided Geometric Design*, 7 (1990): 129-140.
55. T. M. R. Ellis and D. H. McLain. “Algorithm 514 - A Numerical Method of Cubic Curve Fitting Using Local Data.” *ACM Transactions on Mathematical Software*, 3 (1977): 175-178.
56. Gerald E. Farin, G. Rein, N. Sapidis and A. J. Worsey. “Fairing Cubic B-Spline Curves.” *Computer Aided Geometric Design* (1987): 91-103.
57. Gerald E. Farin and Nickolas Sapidis. “Curvature and the Fairness of Curves and Surfaces.” *IEEE Computer Graphics & Applications* (1989): 52-57.
58. Gerald E. Farin. “Smooth Interpolation to Scattered 3D Data.” In *Surfaces in Computer Aided Geometric Design*, ed. R. E Barnhill and W. Böhm, 43-63. North-Holland Publishing Company, 1983.
59. Gerald E. Farin. *Curves and Surfaces for Computer Aided Geometric Design, A Practical Guide*. Academic Press, San Diego, 1990.
60. Gerald E. Farin. “A Construction for Visual C^1 Continuity of Polynomial Surface Patches.” *Computer Graphics and Image Processing*, 20 (1982): 272-282.
61. Gerald E. Farin. “Visually C^2 Cubic Splines.” *Computer-Aided Design*, 14 (May 1982): 137-139.
62. David R. Ferguson, Paul D. Frank and Alan K. Jones. “Surface Shape Control using Constrained Optimization on the B-spline Representation.” *Computer Aided Geometric Design*, 5 (1988): 87-103.
63. David R. Ferguson. “Construction of Curves and Surfaces Using Numerical Optimization Techniques.” *Computer-Aided Design*, 18 (1986): 15-21.
64. James Ferguson. “Multivariable Curve Interpolation.” *Journal of the Association of Computing Machinery*, 11 (April 1964): 221-228.
65. S. D. Fisher and Joseph W. Jerome. “Stable and Unstable Elastica Equilibrium and the Problem of Minimum Curvature.” *Journal of Mathematical Analysis and Applications*, 53 (1976): 367-376.

66. G. Yates Fletcher and David F. McAllister. “An Analysis of Tension Methods for Convexity-Preserving Interpolation.” *IEEE Computer Graphics and Applications*, 7 (August 1987): 7-14.
67. G. Yates Fletcher and David F. McAllister. “Automatic Tension Adjustment for Interpolating Splines.” *IEEE Computer Graphics and Applications*, 10 (January 1990): 10-17.
68. G. Yates Fletcher and David F. McAllister. “Natural Bias Approach to Shape Preserving Curves.” *Computer Aided Design*, 18 (January/February 1986): 48-52.
69. Thomas A. Foley. “Interpolation with Interval and Point Tension Controls Using Cubic ν-Splines.” *ACM Transactions on Mathematical Software*, 13 (March 1987): 68-96.
70. A. R. Forrest. *Curves and Surfaces for Computer-Aided Design.* Ph.D. thesis, Cambridge, 1968.
71. A. R. Forrest. “II. Current Developments in the Design and Production of Three-dimensional curved Objects -- Computational Geometry.” *Proceedings of the Royal Society of London.* Series A. 321 (1971): 187-195.
72. A. R. Forrest. “On Coons and Other Methods for the Representation of Curved Surfaces.” *Computer Graphics and Image Processing*, 1 (1972): 341-359.
73. A. R. Forrest. “On The Rendering of Surfaces.” *Computer Graphics*, 13 (August 1979): 253-259.
74. A. R. Forrest. “The Twisted Cubic Curve: A Computer-Aided Geometric Design Approach.” *Computer Aided Design*, 12 (July 1980): 165-172.
75. David R. Forsey and Richard H. Bartels. “Hierarchal B-spline Refinement.” *Computer Graphics*, 22 (August 1988): 205-212.
76. Frederick N. Fritsch and R. E. Carlson. “Monotone Piecewise Cubic Interpolation.” *SIAM Journal of Numerical Analysis*, 17 (April 1980): 238-246.
77. Frederick N. Fritsch. “Energy Comparisons of Wilson-Folwer Splines with Other Interpolating Splines.” in *Geometric Modeling: Algorithms and New Trends*, ed. G. E. Farin, 185-201. SIAM, 1987.
78. J. M. Glass. “Smooth-Curve Interpolation: A Generalized Spline-Fit Procedure.” *BIT*, 9 (1966): 277-293.
79. Michael Golomb and Joseph Jerome. “Equilibria of the Curvature Functional and Manifolds of Nonlinear Interpolating Spline Curves.” *SIAM Journal on Mathematical Analysis*, 13 (May 1982): 421-458.
80. T. N. T. Goodman and K. Unsworth. “Shape Preserving Interpolation by Curvature Continuous Parametric Curves.” *Computer Aided Geometric Design*, 5 (1988): 323-340.
81. T. N. T. Goodman. “Closed Surfaces Defined from Biquadratic Splines.” *Constructive Approximation*, 7 (1991): 149-160.
82. William J. Gordon and Richard F. Riesenfeld. “B-spline Curves and Surfaces.” In *Computer Aided Geometric Design*, ed. R. E. Barnhill and R. F. Riesenfeld, 95-126. Academic Press, Inc., Orlando, Florida, March 18-21, 1974.
83. William J. Gordon. “Spline-Blended Surface Interpolation Through Curve Networks.” *Journal of Mathematics and Mechanics*, 18 (1969): 931-952.

84. T. Grandine. “An Iterative Method For Computing Multivariate C^1 Piecewise polynomial interpolants.” *Computer Aided Geometric Design*, 4 (1987): 307-319.
85. Ned Greene. “Environment Mapping and Other Applications of World Projections.”, *IEEE Computer Graphics and Applications,* 6 (1986): 21-29.
86. John A. Gregory and Jörg M. Hahn. “A C^2 Polygonal Surface Patch.” *Computer Aided Geometric Design*, 6 (1989): 69-75.
87. John A. Gregory and Peter Charrot. “A C^1 Triangular Interpolation Patch for Computer-Aided Design.” *Computer Graphics and Image Processing*, 13 (1980): 80-87.
88. John A. Gregory, Vincent K. H. Lau and Jianwei Zhou. “Smooth Parametric Surfaces and n-Sided Patches.” In *Computation of Curves and Surfaces*, ed. W. Dahmen, M. Gasca and C. A. Micchelli, 457-498. Kluwer Academic Publishers, Dordrecht, The Netherlands, 1989.
89. John A. Gregory. “Shape Preserving Spline Interpolation.” *Computer Aided Design*, 18 (January/February 1986): 53-57.
90. John A. Gregory. “Smooth Interpolation Without Twist Constraints.” In *Computer Aided Geometric Design*, ed. R. E. Barnhill and R. F. Riesenfeld, 71-87. Academic Press, Inc., Orlando, Florida, March 18-21, 1974.
91. Hans Hagen and Guido Schulze. “Automatic Smoothing with Geometric Surface Patches.” *Computer Aided Geometric Design*, 4 (1987): 231-236.
92. Hans Hagen and Helmut Pottmann. “Curvature Continuous Triangular Interpolants.” In *Mathematical Methods in Computer Aided Geometric Design*, ed. T. Lyche and L. L. Schumaker, 373-384. Academic Press, San Diego, 1989.
93. Hans Hagen. “Bézier Curves with Curvature and Torsion Continuity.” *Rocky Mountain Journal of Mathematics*, 16 (Summer 1986): 629-638.
94. Hans Hagen. “Geometric Spline Curves.” *Computer Aided Geometric Design*, 2 (1985): 223-227.
95. Jörg Hahn. “Filling Polygonal Holes with Rectangular Patches.” Submitted for publication *Theory and Practice of Geometric Modeling*.
96. Jörg M. Hahn. “Geometric Continuous Patch Complexes.” *Computer Aided Geometric Design*, 6 (1989): 55-67.
97. Gary Herron. “Techniques for Visual Continuity.” In *Geometric Modeling: Algorithms and Trends*, ed. G. E. Farin, 163-174. Society for Industrial and Applied Mathematics, Philadelphia, Pennsylvania, 1987.
98. Masatake Higashi, Kohji Kaneko and Mamoru Hosaka. “Generation of High-Quality Curve and Surface with Smoothly Varying Curvature.” *Eurographics 88'* (September 12-16, 1988): 79-92.
99. Klaus Höllig and Harald Mögerle. “G-Splines.” *Computer Aided Geometric Design*, 7 (1990): 197-207.
100. Klaus Höllig. “Geometric Continuity of Spline Curves and Surfaces.” Computer Sciences Technical Report #645, Computer Sciences Department, University of Wisconsin - Madison, June 1986.
101. B. K. P. Horn. “The Curve of Least Energy.” *ACM Transactions on Mathematical Software*, 9 (December 1983): 441-460.

102. Mamoru Hosaka and Fumihiko Kimura. “Non-four-sided Patch Expression with Control Points.” *Computer Aided Geometric Design*, 1 (1984): 75-86.
103. Josef Hoschek. “Detecting Region with Undesirable Curvature.” *Computer Aided Geometric Design*, 1 (1984): 183-192.
104. Joseph W. Jerome. “Smooth Interpolating Curves of Prescribed Length and Minimum Curvature.” *Proceedings of the American Mathematical Society*, 51 (August 1975): 62-66.
105. Barry Joe. “Discrete Beta-Splines.” *Computer Graphics*, 21 (1987): 137-144.
106. Barry Joe. “Multiple Knot and Rational Cubic Beta-Splines.” *ACM Transactions on Graphics*, 8 (April 1989): 100-120.
107. Barry Joe. “Quartic Beta-Splines.” *ACM Transactions on Graphics*, 9 (July 1990): 301-337.
108. A. K. Jones. “Nonrectangular Surface Patches with Curvature Continuity.” *Computer Aided Design*, 20 (July/August 1988): 325-335.
109. Alan K. Jones. “Shape Control of Curves and Surfaces through Constrained Optimization.” In *Geometric Modeling: Algorithms and Trends*, ed. G. E. Farin, 265-279. Society for Industrial and Applied Mathematics (SIAM), Philadelphia, Pennsylvania, 1987.
110. Michael C. Jordan and Frank Schindler. “Curves Under Tension.” *Computer Aided Geometric Design*, 1 (1984): 291-300.
111. Emery D. Jou and Weimin Han. “Minimal Energy Splines with Various End Constraints.” In *Curve and Surface Modeling*. SIAM Frontiers in Applied Mathematics Series. 1990.
112. Emery D. Jou and Weimin Han. “Minimal-energy Splines: I. Plane Curves with Angle Constraints.” *Mathematical Methods in the Applied Sciences*, 13 (1990): 351-371.
113. Jürgen Kahmann. “Continuity of Curvature Between Adjacent Bézier Patches.” In *Surfaces in Computer Aided Geometric Design*, ed. R. E. Barnhill and W. Böhm, 65-75. North-Holland Publishing Company, Amsterdam, The Netherlands, 1983.
114. Michael Kallay. “Method to Approximate the Space Curve of Least Energy and Prescribed Length.” *Computer Aided Design*, 19 (March 1987): 74-76.
115. Michael Kallay and Bahram Ravani. “Optimal Twist Vectors as a Tool for Interpolating a Network of Curves with a Minimum Energy Surface.” *Computer Aided Geometric Design*, 7 (November 1990): 465-473.
116. Johan A. P. Kjellander. “Smoothing of Bicubic Parametric Surfaces.” *Computer Aided Design*, 15 (September 1983): 288-294.
117. Reinhold Klass. “Correction of Local Surface Irregularities Using Reflection Lines.” *Computer-Aided Design*, 12 (March 1980): 73-77.
118. E. H. Lee and G. E. Forsythe. “Variational Study of Nonlinear Spline Curves.” *SIAM review*, 15 (January 1973): 120-133.
119. S. L. Lee and A. A. Majid. “Closed Smooth Piecewise Bicubic Surfaces.” *ACM Transactions on Graphics*, 10 (October 1991): 342-365.

120. Dingyuan Liu. “GC1 Continuity Conditions Between Two Adjacent Rational Bézier Surface Patches.” *Computer Aided Geometric Design*, 7 (1990): 151-163.
121. Charles Loop and Tony DeRose. “A Multisided Generalization of Bézier Surfaces”. *ACM Transactions on Graphics,* 8 (July 1989):204-234.
122. Charles Loop and Tony DeRose. “Generalized Bspline Surfaces of Arbitrary Topology.” *Computer Graphics*, 24 (August 1990): 137-144.
123. N. J. Lott and D. L. Pullin. “Method for Fairing B-spline Surfaces.” *Computer-Aided Design*, 20 (December 1988): 597-604.
124. Augustus Edward Hough Love. *A Treatise on the Mathematical Theory of Elasticity.* 4th ed. Dover, New York, 1944.
125. Michael A. Malcolm. “On the Computation of Nonlinear Spline Functions.” *SIAM Journal of Numerical Analysis*, 15 (April 1977): 254-282.
126. Stephen Mann, Charles Loop, Michael Lounsbery, David Meyers, James Painter, Tony DeRose and Kenneth Sloan. “A Survey of Parametric Scattered Data Fitting Using Triangular Interpolants.” In *Curve and Surface Design*, ed. H. Hagen, 145-172. Society for Industrial and Applied Mathematics, 1992.
127. J. R. Manning. “Continuity Conditions for Spline Curves.” *The Computer Journal*, 17 (1974): 181-186.
128. Samuel P. Marin. “An Approach to Data Parametrization in Parametric Cubic Spline Interpolation Problems.” *Journal of Approximation Theory*, 41 (1984): 64-86.
129. R. R. Martin. “Principal Patches - A New Class of Surface Patch Based on Differential Geometry.” *Eurographics 83'*.
130. Harry W. McLaughlin. “Shape-Preserving Planar Interpolation: An Algorithm.” *IEEE Computer Graphics and Applications* (May/June 1983): 58-67.
131. Even Mehlum and P. F. Sorensen. “Example of an Existing System in the Ship-building Industry: the Autokon System.” *Proceedings of the Royal Society of London.* Series A. 321 (1971): 219-233.
132. Even Mehlum. “A Curve-Fitting Method Based on a Variational Criterion.” *BIT*, 4 (1964): 213-223.
133. Even Mehlum. “Curve and Surface Fitting Based on Variational Criteria for Smoothness.” Central Institute for Industrial Research, Oslo, Norway, 1969.
134. Even Mehlum. “Nonlinear Splines.” In *Computer Aided Geometric Design*, ed. R. E. Barnhill and R. F. Riesenfeld, 173-207. Academic Press, Inc., Orlando, Florida, March 18-21, 1974.
135. H. Meier and H. Nowacki. “Interpolating Curves with Gradual Changes in Curvature.” *Computer Aided Geometric Design* (1987): 297-305.
136. Henry P. Moreton and Carlo H. Séquin. “Surface Design with Minimum Energy Networks.” In *Proceedings Symposium on Solid Modeling Foundations and CAD/CAM Applications*, ed. J. Rossignac and J. Turner, 291-301. ACM Press, New York, 1991.
137. F. Munchmeyer. “On Surface Imperfections.” In *The Mathematics of surfaces II*, 459-474. Oxford University Press, New York, 1987.

138. Ahmad H. Nasri. “Polyhedral Subdivision Methods for Free-Form Surfaces.” *ACM Transactions on Graphics*, 6 (January 1987): 29-73.
139. Ahmad H. Nasri. “Surface Interpolation on Irregular Networks with Normal Conditions.” *Computer Aided Geometric Design*, 8 (1991): 89-96.
140. Gregory M. Nielson. “Some Piecewise Polynomial Alternatives to Splines Under Tension.” In *Computer Aided Geometric Design*, ed. R. E. Barnhill and R. F. Riesenfeld, 209-235. Academic Press, Inc., Orlando, Florida, March 18-21, 1974.
141. Gregory M. Nielson. “A Locally Controllable Spline with Tension for Interactive Curve Design.” *Computer Aided Geometric Design*, 1 (1984): 199-205.
142. Gregory M. Nielson. “A Method for Interpolating Scattered Data Based Upon a Minimum Norm Network.” *Mathematics of Computation*, 40 (January 1983): 253-271.
143. Gregory M. Nielson. “Interactive Surface Design Using Triangular Network Splines.” *Proceedings 3rd International Conference on Engineering Graphics and Descriptive Geometry*, 2 (1988): 70-77.
144. Gregory M. Nielson. “A Transfinite, Visually Continuous, Triangular Interpolant.” In *Geometric Modeling: Algorithms and New Trends*, ed. G. E. Farin, 235-246. Society for Industrial and Applied Mathematics, 1987.
145. Horst Nowacki and D. Reese. “Design and Fairing of Ship Surfaces.” In *Surfaces in Computer Aided Geometric Design*, ed. R. E. Barnhill and W. Böhm, 121-134. North-Holland Publishing Company, Amsterdam, The Netherlands, 1983.
146. Horst Nowacki, Dingyuan Liu and Xinmin Lü. “Fairing Bézier Curves with Constraints.” *Computer Aided Geometric Design*, 7 (1990): 43-55.
147. Horst Nowacki, Dingyuan Liu and Xinmin Lü. “Mesh Fairing GC^1 Surface Generation Method.” In *Theory and Practice of Geometric Modeling* 93-108. Springer-Verlag, 1989.
148. A. W. Nutbourne, P. M. McLellan and R. M. L. Kensit. “Curvature Profiles for Plane Curves.” *Computer Aided Design*, 4 (July 1972): 176-184.
149. Ir. S. C. Ohlin. “Splines for Engineers.” In *Eurographics 87',* 555-565. ed. G. Marechal, North-Holland Publishing Company, Amsterdam, The Netherlands, 1987.
150. Ir. S. C. Ohlin. “2-D and 3-D Curve Interpolation by Consistent Splines.” IBM Nederland NV, CAD/CAM Systems Support Group, March 1985.
151. A. W. Overhauser. “Analytic Definition of Curves and Surface by Parabolic Blending.” Technical Report Number SL68-40, Ford Motor Company Scientific Laboratory, May 8, 1968.
152. T. K. Pal and A. W. Nutbourne. “Two-Dimensional Curve Synthesis Using Linear Curvature Elements.” *Computer Aided Design*, 9 (April 1977): 121-134.
153. T. K. Pal. “Intrinsic Spline Curve with Local Control.” *Computer Aided Design*, 10 (January 1978): 19-29.
154. Theo Pavlidis. “Curve Fitting with Conic Splines.” *ACM Transactions on Graphics*, 2 (January 1983): 1-31.

155. J. Pegna and F. E. Wolter. “A Simple Practical Criterion to Guarantee Second Order Smoothness of Blend Surfaces.” In *Advances in Design Automation - 1989 - Volume One - Computer-Aided and Computational Design*, ed. B. Ravani, ASME, Montreal, Quebec, Canada, September 17-21 1989.
156. Jörg Peters. “Smooth Mesh Interpolation with Cubic Patches.” *Computer Aided Design*, 22 (March 1990): 109-120.
157. Jörg Peters. “Local Generalized Hermite Interpolation by Quartic C2 Space Curves.” *ACM Transactions on Graphics*, 8 (July 1989).
158. Jörg Peters. “Local Smooth Surface Interpolation: A Classification.” *Computer Aided Geometric Design*, 7 (1990): 191-195.
159. Jörg Peters. “Parametrizing Singularly to Enclose Data Points by a Smooth Parametric Surface.”.fixthis518
160. Jörg Peters. “Rectangulation Algorithms: Smooth Surface Interpolation with Bicubics.” CMS Technical Summary Report #90-1, University of Wisconsin, Center for the Mathematical Sciences, July 7, 1989.
161. Jörg Peters. “Smooth Interpolation of a Mesh of Curves.” *Constructive Approximation*, 7 (1991): 221-247.
162. Binh Pham. “Conic Beta-splines with Local Tension Control for Interactive Curve Fitting.” In *Eurographics 88'*, 67-77. North-Holland Publishing Company, Amsterdam, The Netherlands, 1988.
163. David Pilcher. “Smooth Parametric Surfaces.” In *Computer Aided Geometric Design*, ed. R. E. Barnhill and R. F. Riesenfeld, 237-253. Academic Press, Inc., Orlando, Florida, March 18-21, 1974.
164. Bruce R. Piper. “Visually Smooth Interpolation with Triangular Bézier Patches.” In *Geometric Modeling: Algorithms and Trends*, ed. G. E. Farin, 221-233. Society for Industrial and Applied Mathematics (SIAM), Philadelphia, Pennsylvania, 1987.
165. Thomas Poeschl. “Detecting Surface Irregularities Using Isophotes.” *Computer Aided Geometric Design*, 1 (1984): 163-168.
166. Helmut Pottman. “Curves and Tensor Product Surfaces with Third Order Geometric Continuity.” *Proceedings 3rd International Conference on Engineering Graphics and Descriptive Geometry*, 2 (1988): 107-116.
167. Helmut Pottmann. “Smooth Curves Under Tension.” *Computer Aided Design*, 22 (May 1990): 241-245.
168. Helmut Pottmann. “Locally Controllable Conic Splines with Curvature Continuity.” *ACM Transactions on Graphics*, 10 (October 1991): 366-377.
169. Helmut Pottmann. “Scattered Data Interpolation Based upon Generalized Minimum Norm Networks.” #1232, May 1989.
170. Helmut Pottmann. “Visualizing Curvature Discontinuities of Free-Form Surfaces.” *Eurographics 89'* (1989): 529-536.
171. Antti Pramila. “Ship Hull Surface Using Finite Elements.” *International Shipbuilding Progress*, 25 (1978): 97-107.
172. William H. Press, Brian P. Flannery, Saul A. Teukolsky, and WIlliam T. Vetterling. *Numerical Recipes in C*. Cambridge University Press, Cambridge, 1988.

173. M. J. Pratt. “Cyclides in Computer Aided Geometric Design.” *Computer Aided Geometric Design*, 7 (1990): 221-242.
174. Vaughan Pratt. “Techniques for Conic Splines.” *Computer Graphics*, 19 (1985): 151-159.
175. Lyle Ramshaw. “Béziers and B-splines as Multiaffine Maps.” In *Theoretical Foundations of Computer Graphics and CAD*, ed. R. A. Earnshaw, Springer-Verlag, Berlin Heidelberg, 1988.
176. Lyle Ramshaw. “Blossoming: A Connect-the-Dots Approach to Splines.” No. 19, Digital Systems Research Center, June 21, 1987.
177. Thomas Rando and John A. Roulier. “Fair Curves and Surfaces.” In *Approximation Theory VI: Volume 2*, ed. C. K. Chui, L. L. Schumaker and J. D. Ward, 553-556. Academic Press, 1989.
178. Thomas Rando. “Automatic Fairness in Computer Aided Geometric Design.” Ph.D. Dissertation, University of Connecticut, May 1990.
179. Thomas Rando and John A. Roulier. “Designing Faired Parametric Surfaces.” *Computer Aided Design*, 23 (September 1990): 492-497.
180. Dirk Reese. “Fairing of Ship Line and Ship Surfaces.” *Computer Applications in the Automation of Shipyard Operation and Ship Design V*, 11 (1985): 395-399.
181. John A. Roulier. “Bézier Curve of Positive Curvature.” *Computer Aided Geometric Design*, 5 (1988): 59-70.
182. John A. Roulier, Thomas Rando and Bruce Piper. “Fairness and Monotone Curvature.” In *Approximation Theory and Functional Analysis*, ed. C. K. Chui, Academic Press, 1991.
183. M. A. Sabin. “An Existing System in the Aircraft Industry. The British Aircraft Corporation Numerical Master Geometry System.” *Proceedings of the Royal Society of London.* Series A. 321 (1971): 197-205.
184. M. A. Sabin. “Non-Rectangular Surface Patches Suitable for Inclusion in a B-spline Surface.” In *Eurographics 83'*, ed. P. J. W. ten Hagen, 57-69. North-Holland Publishing Company, 1983.
185. H. B. Said. “A Generalized Ball Curve and it Recursive Algorithm.” *ACM Transactions on Graphics*, 8 (October 1989): 360-371.
186. K. Salkauskas. “C^1 Splines for Interpolation of Rapidly Varying Data.” *Rocky Mountain Journal of Mathematics*, 14 (Winter 1984): 239-250.
187. Nicholas Sapidis and G. E. Farin. “Automatic Fairing Algorithm for B-spline Curves.” *Computer Aided Design*, 22 (March 1990).
188. Ramon F. Sarraga. “G1 Interpolation of Generally Unrestricted Cubic Bézier Curves.” *Computer Aided Geometric Design*, 4 (1987): 23-39.
189. R. Schaback. “On Global GC2 Convexity Preserving Interpolation of Planar Curves by Piecewise Bézier Polynomials.” In *Mathematical Methods in Computer Aided Geometric Design*, ed. T. Lyche and L. L. Schumaker, 539-547. Academic Press, San Diego, 1989.
190. A. Schechter. “Synthesis of 2D Curves by Blending Piecewise Linear Curvature Profiles.” *Computer Aided Design*, 10 (January 1978): 8-18.

191. I. J. Schoenberg. “On Variation Diminishing Approximation Methods.” In *On Numerical Approximation*, ed. R. E. Langer, 249-274. The University of Wisconsin Press, Madison, Wisconsin, 1959.

192. Larry A. Schumaker. “On Shape Preserving Quadratic Spline Interpolation.” *SIAM Journal of Numerical Analysis*, 20 (August 1983): 854-864.

193. Daniel G. Schweikert. “An Interpolation Curve using a Spline in Tension.” *Journal of Mathematics and Physics*, 45 (1966): 312-317.

194. Dino Schweitzer. “Artificial Texturing: An Aid to Surface Visualization.” *Computer Graphics*, 17 (July 1983): 23-29.

195. Carlo H. Séquin. “Procedural Spline Interpolation in UNICUBIX.” Report No. UCB/CSD 87/321, Computer Science Division (EECS), University of California, Berkeley.

196. Leon A. Shirman and Carlo H. Séquin. “Local Surface Interpolation with Shape Parameters Between Adjoining Gregory Patches.” *Computer Aided Geometric Design,* 7 (August 1990): 375-388

197. Leon A. Shirman and Carlo H. Séquin. “Procedural Interpolation with G^1 and G^2 Cubic Splines.” *Proceedings of the SIAM Conference on Geometric Design* (November 1989).

198. Leon A. Shirman. “Construction of Smooth Curves and Surfaces from Polyhedral Models.” UCB/CSD 90/602 Ph.D. Thesis, University of California at Berkeley.

199. Leon Shirman and Carlo H. Séquin. “Local Surface Interpolation with Bézier Patches.” *Computer Aided Geometric Design*, 4 (1987): 279-295.

200. Leon A. Shirman and Carlo H. Séquin. “Procedural Construction of Patch-Boundary Curves.” In *Curves and Surfaces*. Academic Press, Boston, 1991.

201. S. T. Tan and K. C. Chan. “Bi-quadratic B-spline Surfaces Generated from Arbitrary Polyhedral Meshes: A Constructive Approach.” *Computer Vision, Graphics, and Image Processing*, 39 (1987): 144-166.

202. Feodor Theilheimer and William Starkweather. “The Fairing of Ship Lines on a High-Speed Computer.” *Mathematics of Computation*, 15 (October 1961).

203. Wayne Tiller. “Rational B-Splines for Curve and Surface Representation.” *IEEE Computer Graphics and Applications* (September 1983): 61-69.

204. P. H. Todd and R. J. Y. McLeod. “Numerical Estimation of the Curvature of Surfaces.” *Computer-Aided Design*, 18 (January, February 1986): 33-37.

205. M. Veron, G. Ris and J. P. Musse. “Continuity of Biparametric Surface Patches.” *Computer Aided Design*, 8 (October 1976): 267-273.

206. Kenneth James Versprille. *Computer-Aided Design Applications of the Rational B-spline Form.* Ph.D. Thesis, Department of Computer Science, Syracuse University, 1975.

207. A. Vinacua and P. Brunet. “A Construction for VC1 Continuity of Rational Bézier Patches.” In *Mathematical Methods in Computer Aided Geometric Design*, ed. T. Lyche and L. L. Schumaker, 601-611. Academic Press, San Diego, 1989.

208. Jarke J. Van Wijk. “Bicubic Patches for Approximating Non-Rectangular Control-Point Meshes.” *Computer Aided Geometric Design*, 3 (1986): 1-13.

209. C. J. K. Williams. “Use of Structural Analogy in Generation of Smooth Surfaces for Engineering Purposes.” *Computer-Aided Design*, 19 (July-Aug. 1987): 310-22.
210. S. Wolfram. *Mathematica, A System for Doing Mathematics by Computer.* 2d ed. Addison-Wesley, Redwood City, CA, 1991.
211. C. H. Woodford. “Smooth Curve Interpolation.” *BIT*, 9 (1969): 69-77.