A New Method of Solving the Bernoulli Quadrisection Problem and Its Application to Other Problems in Euclidean Geometry

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The Bernoulli Quadri-section Problem involves the division of the area of a given triangle into four equal areas, a triangle and three quadrilaterals, using two perpendicular straight lines. We show that this problem can be recast as one requiring the minimization of a function of several variables, and we use a modern, very efficient minimization algorithm, Particle Swarm Optimization (PSO) to solve it. We also show that several other famous and difficult problems, for example, the Malfatti Circles Problem and the Tenth Problem of Apollonius, can be solved in a similar manner. Although our project was inspired by problems that have a long history in Mathematics, we also discuss a new method of solving a very modern problem. This problem was proposed and solved by Professor Jens Vygen (University of Bonn) in 2005. It has applications in the design of electronic circuits using Very Large-Scale Integration (VLSI). We present a very different method of solution based on PSO. Our solution of this VLSI problem required us to develop a modified PSO algorithm involving the use of multiple particle swarms. This experience encouraged us to develop a number of new, very efficient particle swarm algorithms. Packing problems arise in many industrial processes. Optimal solutions are known to be very difficult to achieve in most cases. A problem that has received a lot of attention, and which is amenable to solution using our multiple swarms algorithm, is that of packing equal circles into a square.

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