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Solving the forward kinematics of parallel robots, a review of available methods

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Considering the success of the Delta and Quattro robots, parallel robots have surely contributed to material handling through improved performance. Parallel robots offer stiffer mechanisms which can be designed with either greater acceleration capacity or smaller energy and power levels. However, they continue to pose a serious challenges when considering their kinematics.The typical spatial parallel manipulator is the hexapod constituted by six kinematics chains located between a fixed and mobile platform, classified as the Gough platforms or 6-6 general manipulators and referred to the Stewart platform. The inverse kinematics problem (IKP) yield a simple closed-form explicit solution. Solving the forward kinematics problem (FKP) of general parallel manipulators is still considered a challenge, obtained by finding the real roots of a non-linear equation system constructed from the IKP.There methods can be classified as numerical methods, algebraic methods and evolutionary computations. Many numerical methods can solve non-linear systems. The Newton-Raphson method was first implemented with the advantage of its very rapid convergence. But, it can converge to only one real root and numerical instabilities can easily make it to fail. To determine all real roots, intervals were implemented. But, these methods are often plagued by the usual Jacobian inversion problems and thus cannot guarantee to find solutions in all non-singular instances. Bisection and secant methods can also be advocated with slower convergence. However, bisection can be guaranteed to find a solution. The geometric iterative method has shown promises but it needs a proper initial guess. Lazard, Ronga and Mourrain have then proven that the FKP has 40 complex solutions using, respectively, Gröbner bases, Chern classes of vector bundles and explicit elimination techniques. Computer algebra was then selected in order to manipulate exact intermediate results and solve the issue of numeric instabilities related to round-off errors so common with purely numerical methods. Husty and Wampler used variable elimination techniques such as resultants to solve the FKP for the general Gough platform with success. However, resultant or dialytic elimination can add spurious solutions, and it will be demonstrated how these can be hidden in the polynomial leading coefficients. Inasmuch, a sole univariate polynomial cannot be proven equivalent to a complete system of several polynomials. The continuation method was then applied to find the solutions, but they are prone to miss some solutions. Later, the SSM hexapod FKP was solved with genetic algorithms and the general 6-6 hexapod FKP was recenlty solved by the author where several solutions could be found. Combination of GAs with simulated annealing improved performance and allowed to find all solutions.This paper covers the state-of-the-art on solving the forward kinematics problems presenting advantages and problem.

Biography

Luc Rolland is actually an associate professor in Mechatronics for the faculty of engineering at Memorial University of Newfoundland. In December 1984 and September 1987, he graduated in Mechanical Engineering from the Montreal Polytechnic Engineering School. In, he obtained his Master's degree in Robotics Simulation from the same School, funded by CAMCO, a General Electric subsidiary. Since then, he has been a member of the Quebec's Engineering Corporation. In July 1996, as a research assistant at the Federal Polytechnic Engineering School of Lausanne, he invented the first 4-d.o.f. parallel manipulators with Schoenflies motion, the Kanuk and the Manta.Later, he has received his Ph.D. diploma in computer science from Henri Poincare University in France, with a bursary from the INRIA with technology transfer to CMW-Marioni and has been awarded two Medals of Honors. He has been a reviewer for six International Journals. He is author or co-author of over 20 publications. Prior to his academic career, he has practiced as a professional engineer for ten years in instrumentation, automation and control projects.

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