***Efficient Gröbner Basis Computations for Polynomial Systems in Robotics***

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Robot locomotion planning and control involves solving systems of polynomial equations associated with inverse kinematics and dynamics problems for robots. Gröbner basis algorithms generalize Gaussian elimination for multivariate polynomials and can be used to solve systems of polynomial equations, but these algorithms have a double exponential worst-case complexity. Alternatives to the computationally expensive Gröbner basis algorithms include numerical methods, such as homotopy-continuation, but numerical methods do not reliably yield exact solutions.

We analyzed Gröbner basis algorithms that leverage the sparsity of the polynomial systems for our multi-leg spider robot. We compared sparsity-leveraging Gröbner basis algorithms, such as Buchberger’s algorithm, Faugère's F4, F5 and FGLM, and studied the performance of these algorithms in MATLAB, Maple, Macaulay2 and Sage. Despite the complexity of Gröbner basis computations, we achieved a 50 milliseconds computation time for Gröbner basis for a system of 128 polynomials for our spider robot using Sage on a 1.3 GHz processor. We aim to apply our advances in Gröbner basis computations to improve the performance of humanoid robots, such as Boston Dynamics Atlas, and investigate chordal graphs to further leverage polynomial structure in Gröbner basis algorithms.