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Geometric Computing for Cybernetics

Summary

In this talk we present an advanced new mathematical framework, the conformal geometric al-gebra for applications in computer vision, graphics engineering, control engineering, robotics and machine learning. We will show that this mathematical system keeps our intuitions and insight of the geometry of the problem at hand and it helps us to reduce considerably the computational burden of the problems.

Surprisingly, as opposite to the standard projective geometry, in conformal geometric algebra we can deal simultaneously with incidence algebra operations (meet and join) and conformal transformations represented effectively using spinors (a kind of quaternions, dual quaternions, etc). In this regard this framework appears promising for dealing with representation, kinematics, dynamics, projective geometry and Riemann differential geometry problems without the need to abandon the mathematical system (as current approaches). We present some real tasks of perception and action treated in a very elegant and efficient way: body—eye calibration, 3D reconstruction and robot navigation and visually guided 3D object grasping, walking pattern generation and biped walking control making use of the directed distance and intersections of lines, planes and spheres both involving conformal transformations. For tracking, we use the Motor (dual quaternion) extended Kalman filter and for control problems we reformulate the differential geometry and the Jacobian based control rule for 6 D. O. F. robot arms using conformal geometric algebra. At the final part of the talk we will also present the design of an applications of geometric neural networks, geometric NGAS and the Multi-vector Support Vector Machines (generalization of MIMO SVMs) useful for learning in visual guided robotics and medical robotics. We will comment our current work on geometric spike neurons to system identification and control for humanoid behavior control.

The lecturer believes that the framework of geometric algebra can be in general of great advantage for applications in image processing, graphics engineering, stereo vision, compress sensing, deep-learning, range data, laser, omnidirectional, laser and odometry based robotic systems (robot manipulators, mobile and humanoids), kinematics and dynamics of robot mechanisms, cognitive robotics, and advanced nonlinear control techniques.