Abbreviations

AMD.................................................................................................................. Advanced Micro Devices
ATM.................................................................................................................. Arc Transversal Median
CAD.................................................................................................................. Computer Aided Design
CCD.................................................................................................................. Charge Coupled Device
COG.................................................................................................................. Centre Of Gravity
COM.................................................................................................................. Communications
I/O.................................................................................................................. Input / Output
JIRA................................................................................................................. Japanese Industrial Robot Association
LSA.................................................................................................................. Logical Sensor / Actuator
NIDAQ.......................................................................................................... National Instruments Digital Acquisition
PC.................................................................................................................. Personal Computer
PCL.................................................................................................................. Peripheral Component Interconnect
RGB............................................................................................................. Red Green Blue
RMA................................................................................................................. Royal Military Academy
PII.................................................................................................................. Intel Pentium 2
SDRAM............................................................................................................ Synchronous Dynamic Random Access Memory
SMPA............................................................................................................. Sense Model Plan Act
US.................................................................................................................. Ultrasonic Sensor
VISCA.......................................................................................................... Video System Control Architecture
XOR.................................................................................................................. Exclusive Or
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[13] “An Introduction to the Kalman Filter” by Greg Welch and Gary Bishop, University of North Carolina, Department of Computer Science, Chapel Hill, USA, 1996


[15] “Path Planning Using Laplace’s Equation” by C.I. Connolly, J.B. Burns and R. Weiss, University of Massachusetts, Computer and Information Science Department, Amherst, USA, February 1994

[16] “Generating Sonar Maps in Highly Specular Environments” by Andrew Howard and Les Kitchen, University of Melbourne, Department of Computer Science, Victoria, Australia, 1992
References


[18] “Deadlock-Free Motion Planning using the Laplace Potential Field” by Keisuke SATO, University of Tokyo, Tokyo, Japan, 1988


[22] “Ultrasonic Mobile Robot Perception using Neural Network Techniques” by Jie Chen, University of Ghent, Department of Electronics and Information Systems, Gent, Belgium, 1996

[23] “Véhicule autonome guide” by Bey Temsamani Abdellatif, Université de Mons – Hainaut, Mons, Belgium, 1996
