A Mathematical Notation

Symbol	Meaning
$\cdot$	dot product
$\exists$	there exists
$\forall$	for all
∞	infinity
$\in$	element
$\notin$	not in
s.t.	such that
$\mathbb{R}$	real numbers
$\mathbb{R}^m$	m-dimensioned real numbers
$\bigcup$	union
$\bigcap$	intersection
$\setminus$	set difference
$\Rightarrow$	implies. $p \Rightarrow q$ is p implies q
$\Longleftrightarrow$	if and only if
S^1	a circle
∇	gradient
D	differential or distance to closest obstacle (depending on context)
d_i	distance to obstacle i in either the workspace or configuration space (depending on context)
$d(x, y)$	distance between the two points x and y
Null	null space

$O(n)$	order of n
J	Jacobian
Γ	Christoffel symbol
RM	roadmap
$\mathcal{W}$	workspace
$\mathcal{Q}$	configuration space
$\mathcal{Q}_{\text{free}}$	free space
$x(k)$	state at time k
$\|\|x\|\|$	norm of x
$\subseteq$	subset of
$\subset$	strict subset of
$\text{cl}(A)$	closure of A
T^n	n-dimensional torus
S^n	n-dimensional sphere in $\mathbb{R}^{n+1}$
$SO(n)$	special orthogonal group
$SE(n)$	special Euclidean group
$B_\epsilon(q)$	open ball of radius ϵ centered at q
Df	differential of f
∇f	gradient of f
∇	affine connection
$\nabla_{Y_1} Y_2$	covariant derivative of Y_2 with respect to Y_1
C^0	continuous
C^n	n times differentiable
$\langle x, y \rangle$	inner product of x and y
$\mathcal{I}$	identity matrix
$\text{atan2}(y, x)$	returns angle to (x, y) in the plane in range $[-\pi, \pi)$
$T_x\mathcal{M}$	tangent space of $\mathcal{M}$ at x
$T\mathcal{M}$	tangent bundle of $\mathcal{M}$
$[f, g]$	Lie bracket of vector fields f, g
$\overline{\text{Lie}}(\mathcal{G})$	the Lie algebra of a set of vector fields $\mathcal{G}$
$\overline{\mathcal{D}}$	involutive closure of the distribution $\mathcal{D}$
$\mathcal{U}_\pm$	control set positively spanning $\mathbb{R}^m$
$\mathcal{U}_+$	control set spanning $\mathbb{R}^m$
$\langle Y_1 : Y_2 \rangle$	the symmetric product of vector fields Y_1 and Y_2
$\overline{\text{Sym}}(\mathcal{Y})$	the symmetric closure of the distribution $\mathcal{Y}$
$\text{span}(\{x_1, \ldots, x_n\})$	the linear span of $\{x_1, \ldots, x_n\}$