Force Reaction Fitness Metrics

Table 8: Variable Definitions

Variable	description	unit
m_e	effective mass (reflected inertia)	kg
m_load	additional mass loaded to the test device	kg
n_d	number of detected contacts	-
$n_\mathrm{d,t}$	number of detected contacts for tactile collision sensitivity	-
N_c	amount of conducted collision tests	-
$N_\mathrm{c,t}$	amount of conducted collisions for tactile collision sensitivity	-
$N_\mathrm{m_e}$	total amount of effective mass settings for the experiment	-
$N_{\dot{\mathbf{x}}}$	total amount of velocity settings for the experiment	-
$N_{\dot{\mathbf{x}},\mathrm{t}}$	total amount of velocity settings for the tactile experiment series	-
u	step function	-
$\dot{\mathbf{x}}$	velocity	$\mathrm{m/s}$
x_b	braking distance	mm
x_t	distance threshold	mm

Table 9: Metric Definitions

Metric	name	description	eq.	unit	best[3]
CS	Contact Sensitivity	capability to react to contact forces in free motion to prevent primary or secondary hazards to humans after collision	$\frac{n_\mathrm{d}}{N_\mathrm{c}}\,,\quad n_\mathrm{d} = \sum_{i=1}^{N_\mathrm{c}} u\left(\frac{1}{N}\sum_N u\left(\frac{1}{x_\mathrm{b}-x_\mathrm{t}}-1\right)\right)\,,\quad N_\mathrm{c} = N_\mathrm{m_e} N_{\dot{\mathbf{x}}}\,,$	$\%$	100
$\mathrm{CS_t}$	Tactile Contact Sensitivity	capability to react to contact forces in cluttered space to detect objects	$\frac{n_\mathrm{d,t}}{N_\mathrm{c,t}}\,,\quad n_\mathrm{d,t} = \sum_{i=1}^{N_\mathrm{c,t}} u\left(\frac{1}{N}\sum_N u\left(\frac{1}{x_\mathrm{b}-x_\mathrm{t}}-1\right)\right)\,,\quad N_\mathrm{c} = N_\mathrm{m_e} N_{\dot{\mathbf{x}},\mathrm{t}}$	$\%$	100

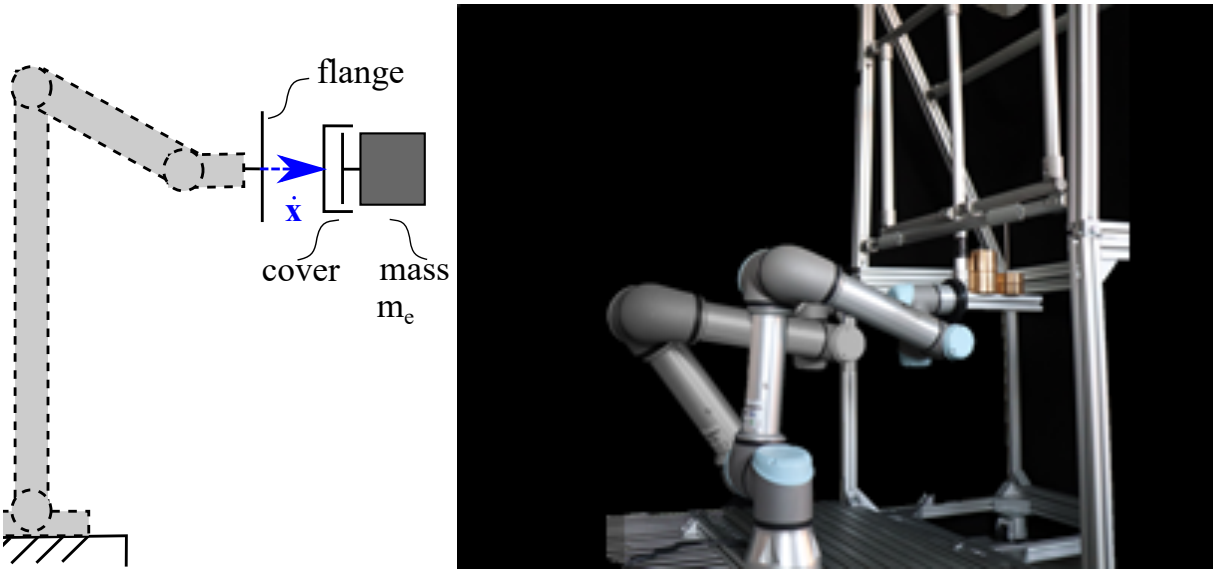

Figure 12: Reference system for the contact sensitivity metrics.

Table 10: Setup definitions

component	**considered quantity**	**value**	**accuracy req.**
threshold x_{t}	distance [mm]	10	$\pm$ 1
contact velocities $\|\dot{\mathbf{x}}\|$	velocity [m/s]	0.05	$\pm$ 0.01
		0.10	$\pm$ 0.01
		0.15	$\pm$ 0.01
		0.20	$\pm$ 0.01
		0.25	$\pm$ 0.01
		0.35	$\pm$ 0.01
		0.40	$\pm$ 0.01
		0.45	$\pm$ 0.01
		0.50	$\pm$ 0.01
		0.55	$\pm$ 0.01
		0.60	$\pm$ 0.01
		0.65	$\pm$ 0.01
effective masses m_{e} (by load m_{load}	mass [kg]	1.2 (0.0)	$\pm$ 0.1
		1.9 (1.0)	$\pm$ 0.1
		2.8 (2.0)	$\pm$ 0.1
		3.6 (3.0)	$\pm$ 0.1
		4.3 (4.0)	$\pm$ 0.1
		5.0 (5.0)	$\pm$ 0.1
		5.7 (6.0)	$\pm$ 0.01

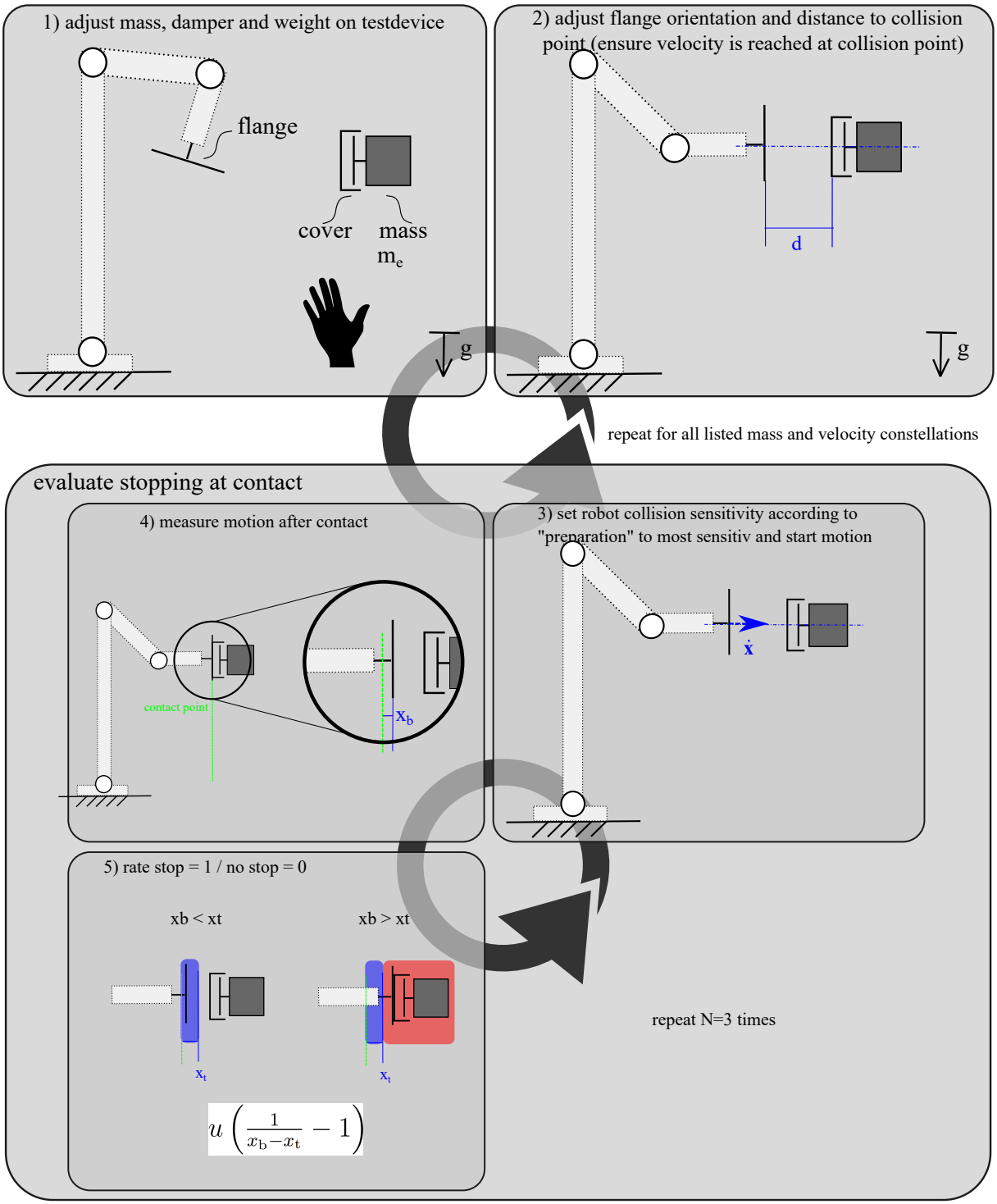

Figure 13: Measurement Procedure for CS and CSt.