# A haptic guidance generic approach

Alexis Boulay[1,2], Margot Vulliez [1], David Daney[1]

[1]*Inria, Bordeaux, France* [2]*Farm3, Besançon, France*

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Known as virtual fixture, active constraint or virtual guide, a haptic guidance is a virtual geometric constraint used to generate a force feedback that force an user following a behaviour. The different definitions are strongly linked to the tasks studied whether surgery, navigation or pick&place. They also are not limited to teleoperation but can be use on physical human robot interaction and programming by demonstration. This task dependency highlights that there is no unified formalism to model haptic guidance. Perhaps, common computation methods can be identified for the generation of guide such as the use of spring-damper models (SD), the definition of potential fields (PF) or the establishment of restrictive zones with guiding tubes (GT). This work aims at defining a generic method that encompass these conventional haptic guidance.

Considering stiffness and damping coefficients $K_g$ and $B_g$, but also $\dot{\mathbf{X}}_h$ the haptic device velocity, $d_g$ a distance threshold, $d_{d,r} = ||\mathbf{X}_{d,r} - \mathbf{X}_r||$ the distance between the position of the robot and the desired task position (a pose, a point on an trajectory, a point on a plan,...) and $\mathbf{\Delta}_{d,r}$ the direction to this desired position. The three main haptic guidance can be express as a force:

$$\mathbf{F}_g = K_g f(d_{d,r})\mathbf{\Delta}_{d,r} - B_g\dot{\mathbf{X}}_h \tag{1}$$

The expression of $f(d_{d,r})$ changes with respect to the type of guidance. Thus:

$$f_{SD}(d_{d,r}) = d_{d,r}; f_{PF}(d_{d,r}) = \begin{cases} \frac{d_{d,r}}{{d_g}^2} & if\ d_{d,r} \leq d_g \\ \frac{1}{d_{d,r}} & else \end{cases}; f_{GT}(d_{d,r}) = \begin{cases} 0 & if\ d_{d,r} \leq d_g \\ (d_{d,r} - d_g) & else \end{cases} \tag{2}$$

Each type of guidance has its pros and cons. Overall, SD prevents you from leaving the desired point/trajectory, GT lets you free around the desired point/trajectory until you reach a determined distance, and PF helps you find the desired point/trajectory while you can freely explore space. Yet GT and PF expressions have discontinuities, and SD makes it difficult for several objectives to coexist. Since each guidance has different qualities, it can be useful to change the guidance while executing a task.

This work proposes an expression of $f(d_{d,r})$ that allows for easily and continuously switching between each type of guidance :

$$f_{RG}(d_{d,r}) = a\frac{d_{d,r}}{(d_g)^b}\exp(1 - (\frac{d_{d,r}}{d_g})^c) \tag{3}$$

The parameters $a$, $b$, and $c$, allow to transit smoothly between different types of guidance, for example $a = 1$, $b = 0$ and $c = 0$ correspond to a SP.

By implementing such a generic expression referred as ruling guidance (RG), it is possible to dynamically adapt the guidance, depending on the task, the environmental constraints or the user preferences. We could even explore intermediate guidance and propose and optimal guidance according to these parameters.