A haptic guidance generic approach

Alexis Boulay, David Daney, Margot Vulliez, Romain Schmitt, Arthur Bonastre

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Alexis Boulay, 2nd year CIFRE PhD student with Farm3

Inria supervisors : David Daney , Margot Vulliez
Auctus Inria, F-33405 Talence, France

Farm3 supervisors : Romain Schmitt, Arthur Bonastre
Farm3, F-25300 Verrières-de-Joux, France

contact : alexis.boulay@inria.fr

Context

Teleoperation : Allow a human to take control of the robot for remote operation. ⇨ **How to ensure interaction performances?**

Shared autonomy : Enable some robot autonomy for specific simple tasks. ⇨ **How to assist a human with more difficult tasks ?**

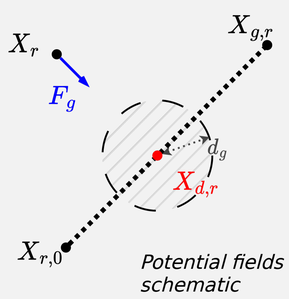
Haptic guidance : Generate a force that guides the user to follow a behaviour.

⇨ **What are the different computation methods for haptic guidance and how can a generic approach be defined ?**

Potential fields

Attract or repel operator to a position

- Allow multiple targets
- Free space exploration
- Local minimum



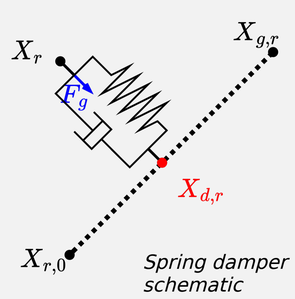
Potential fields schematic

⇨ $$\mathrm{f}_{PF}(d_{d,r}) = \begin{cases} \frac{d_{d,r}}{{d_g}^2} & if\ d_{d,r} \leq d_g \\ \frac{1}{d_{d,r}} & else \end{cases}$$

Spring damper

Attach operator to a path

- Unique target
- Allow obstacle avoidance
- Stable



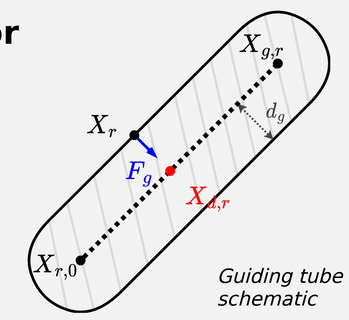
Spring damper schematic

⇨ $$\mathrm{f}_{SD}(d_{d,r}) = d_{d,r}$$

Guiding tube

Prevent operator from leaving an area

- Multiple geometry
- Limited free space
- Stable



Guiding tube schematic

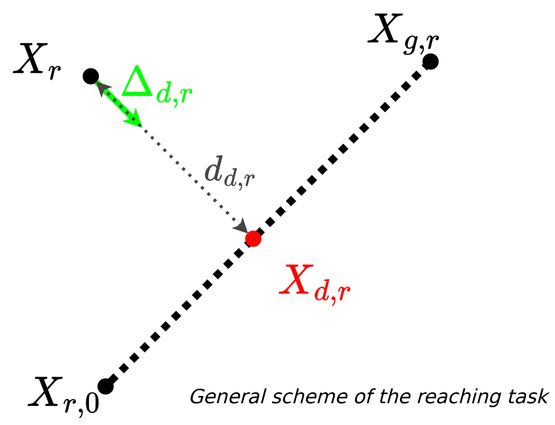
⇨ $$\mathrm{f}_{GT}(d_{d,r}) = \begin{cases} 0 & if\ d_{d,r} \leq d_g \\ (d_{d,r} - d_g) & else \end{cases}$$

Virtual fixture

Geometric constraint used to generate a haptic guidance

- **$f(d_{d,r})$** is the **attraction function** associated with the generic guidance equation, it depends of the distance **$d_{d,r}$** between **X_r** the robot position and **$X_{d,r}$** the desired position
- **K_g** and **B_g** are generic **impedance** and **damping gains** that can be designed to constrain some directions
- **$\dot{X}_h$** is the **haptic device velocity**, it is used for damping to obtain a better reactivity

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

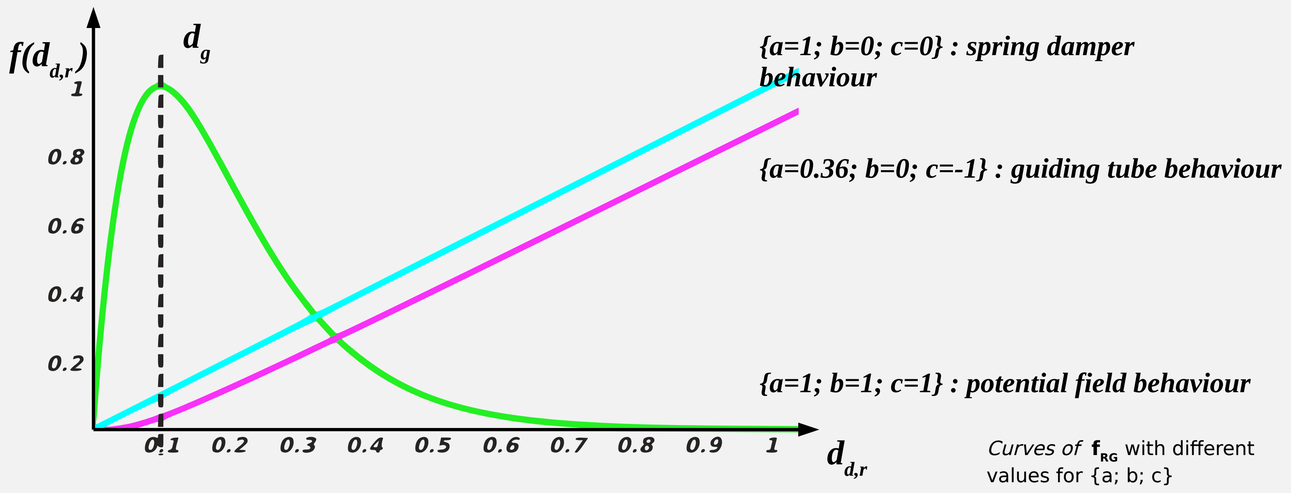


General scheme of the reaching task

Ruling guidance

Use of a generic, parameterised and continuous attraction function

⇨ $$\mathrm{f}_{RG}(d_{d,r}) = a \frac{d_{d,r}}{(d_g)^b} \exp(1 - (\frac{d_{d,r}}{d_g})^c)$$



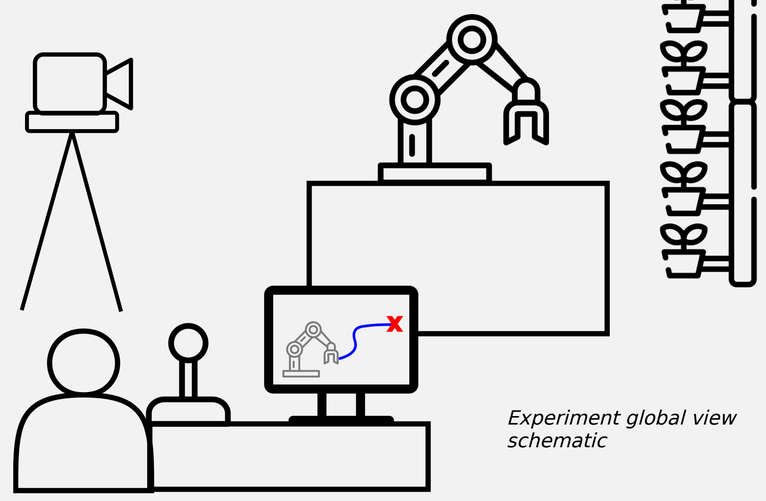
Curves of $\mathbf{f_{RG}}$ with different values for {a; b; c}

- **Continuous** change between the different types of guidance
- Exploration of **intermediate guidance**
- Provide **optimal guidance** relative to the task, the operator and the environment

Experiment

A future experiment will implement and compare different parameterisation of the ruling guidance, and try to define the optimal guidance considering, task, environment and user.

It consists of reaching a plant position in a vertical farm in different scenarios.


Experiment global view schematic