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A haptic guidance generic approach

Alexis Boulay, 2nd year CIFRE PhD student with Farm3

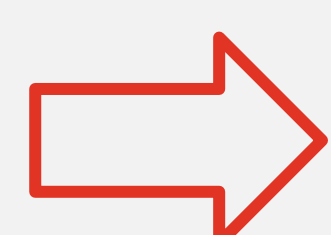
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Context

- 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.

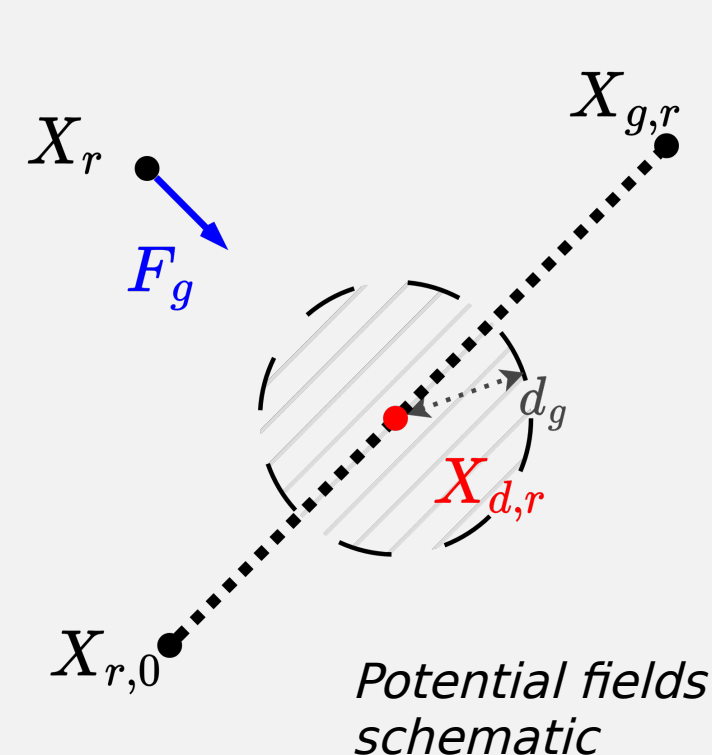


What are the different computation methods for haptic guidance and how can a generic approach be defined ?

Potential fields

Attract or repel operator to a position

- Allow multiple targets
- Free space exploration
- Local minimum

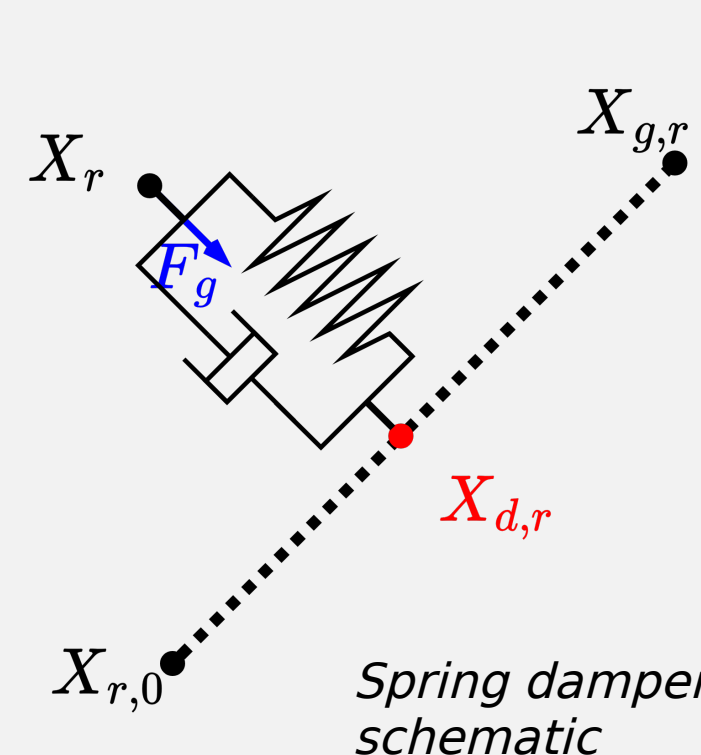


$$f_{PF}(d_{d,r}) = \begin{cases} \frac{d_{d,r}}{d_g^2} & \text{if } d_{d,r} \leq d_g \\ \frac{1}{d_{d,r}} & \text{else} \end{cases}$$

Spring damper

Attach operator to a path

- Unique target
- Allow obstacle avoidance
- Stable

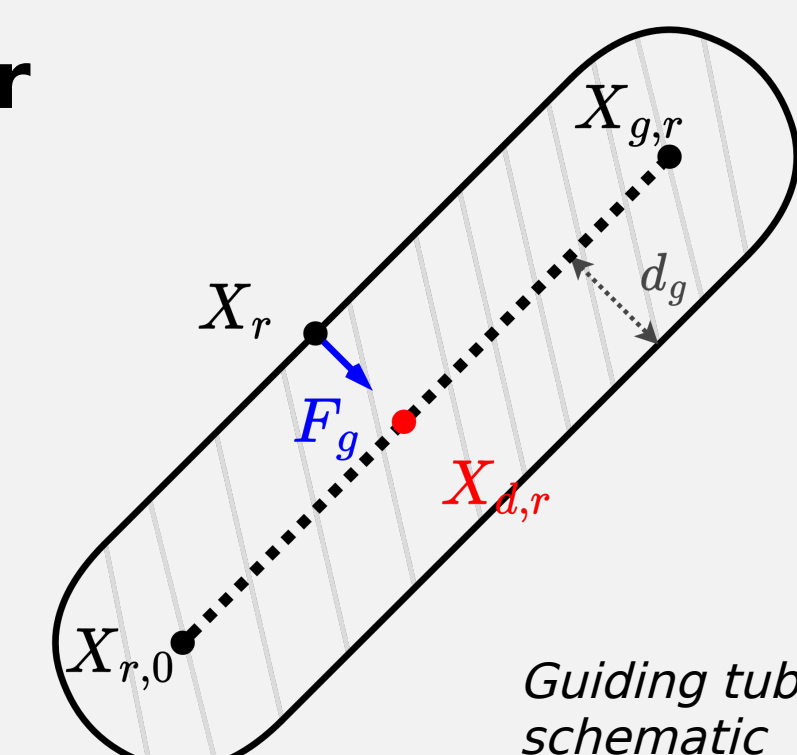


$$f_{SD}(d_{d,r}) = d_{d,r}$$

Guiding tube

Prevent operator from leaving an area

- Multiple geometry
- Limited free space
- Stable



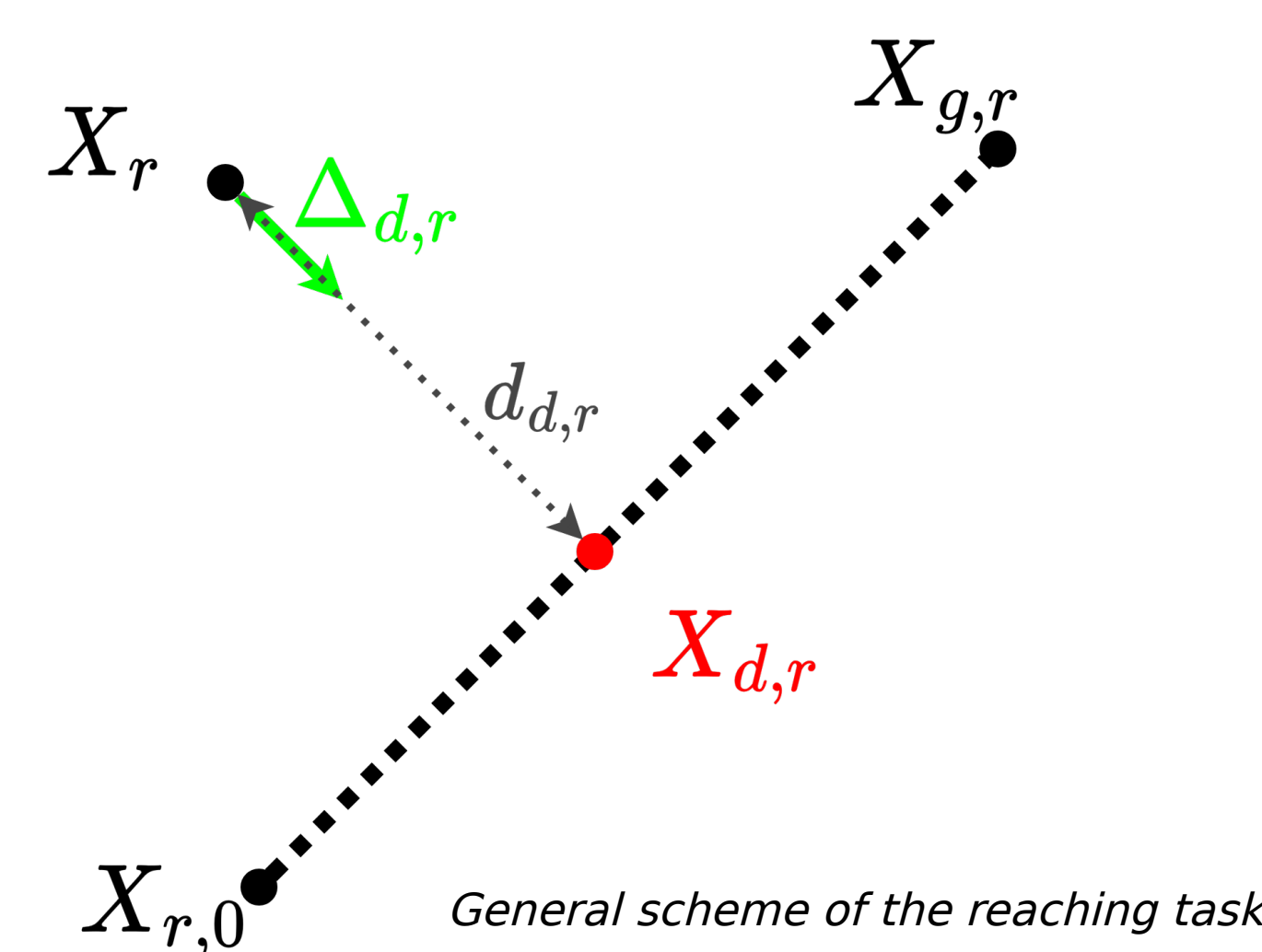
$$f_{GT}(d_{d,r}) = \begin{cases} 0 & \text{if } d_{d,r} \leq d_g \\ (d_{d,r} - d_g) & \text{else} \end{cases}$$

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

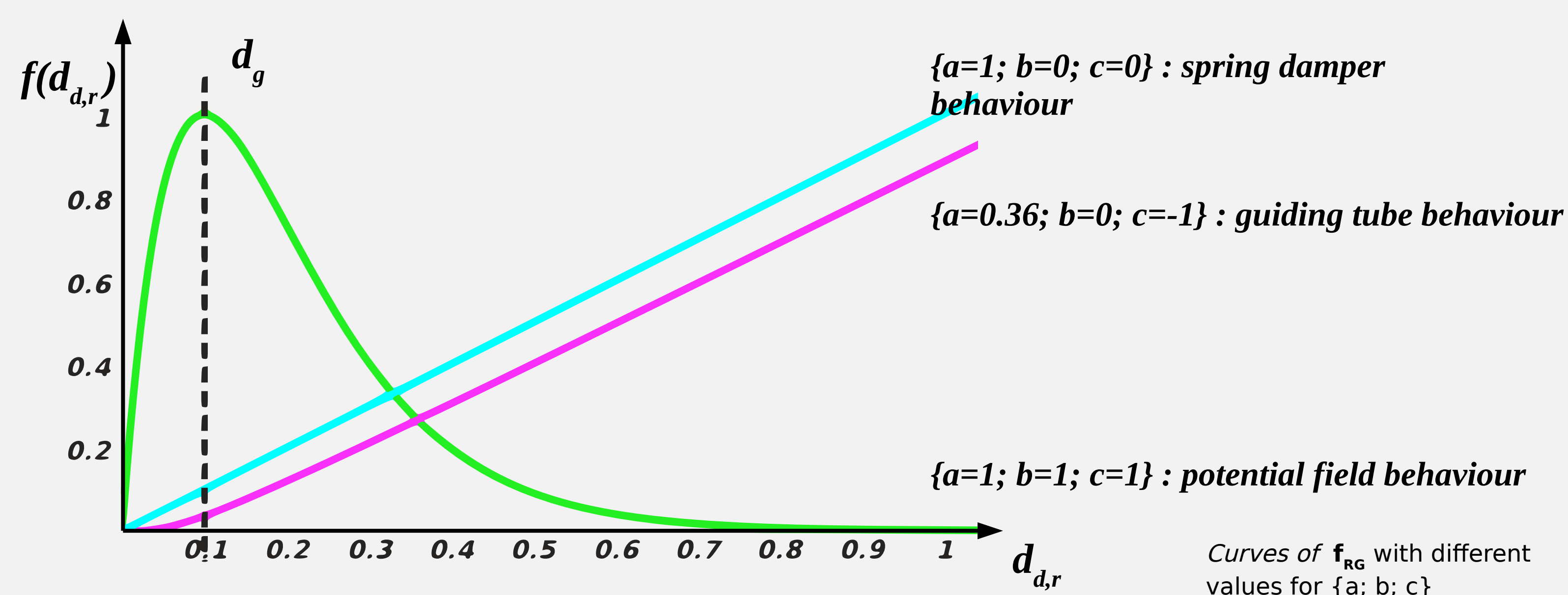
$$F_g = K_g f(d_{d,r}) \Delta_{d,r} - B_g \dot{X}_h$$



Ruling guidance

Use of a generic, parameterised and continuous attraction function

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



- **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.

