

Manipulation and Skill Learning and Generalizing

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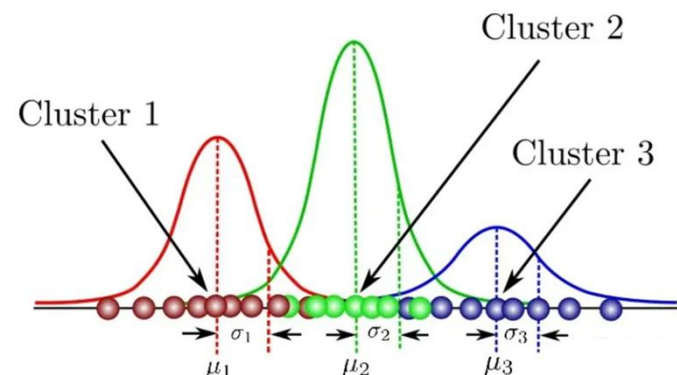
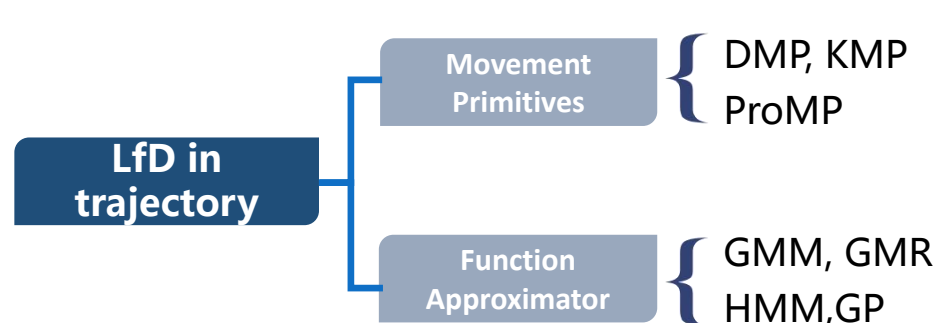
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Learning from Demonstration

Definition: Learning from demonstration (LfD) is the paradigm in which robots acquire new skills by learning to imitate an expert in the context of robotics and automation.

- ❑ Kinesthetic teaching
- ❑ Teleoperation
- ❑ Passive observation
- ❑ Active and Interactive Demonstrations





Learning from Demonstration

□ Dynamic Movement Primitive

– Nonlinear Dynamic System:

$$\tau \begin{bmatrix} \ddot{z} \\ \dot{x} \end{bmatrix} = \begin{bmatrix} \alpha_z(\beta_z(g - z) - \dot{z}) + f(x, g) \\ -\alpha_x x \end{bmatrix}$$

– Forcing Function:

$$f(x, g) = \left(\sum_{i=1}^N \psi_i \cdot \frac{\omega_i}{\sum_{i=1}^N \psi_i} \right) x(g - z_0)$$

– Basis Function Weight:

$$\omega_i = \frac{s\psi_i f_{target}}{s\psi_i s^T}$$

□ Gaussian Mixture Model and Gaussian Mixture Regression (GMM-GMR)

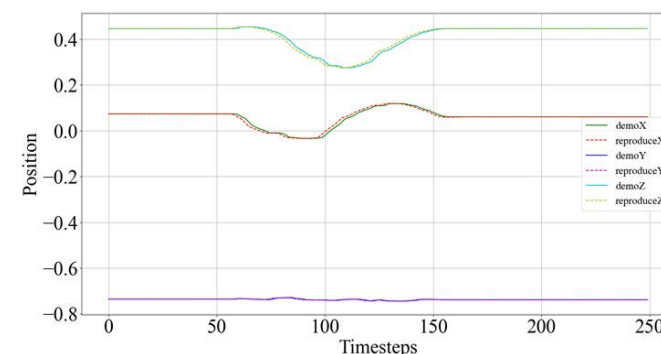
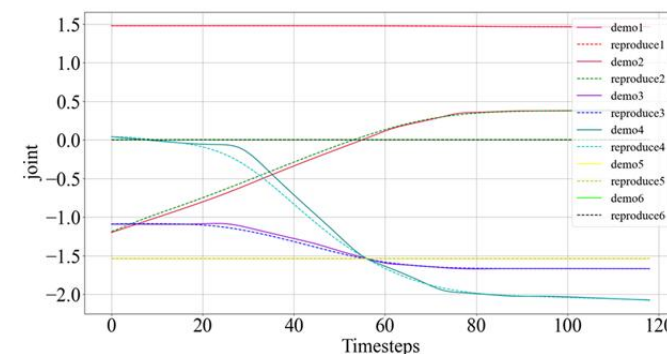
– Joint Probability Distribution:

$$P(s, \xi) \sim \sum_{c=1}^C \pi_c N \left(\mu_c, \sum_c \right)$$

– Gaussian Component:

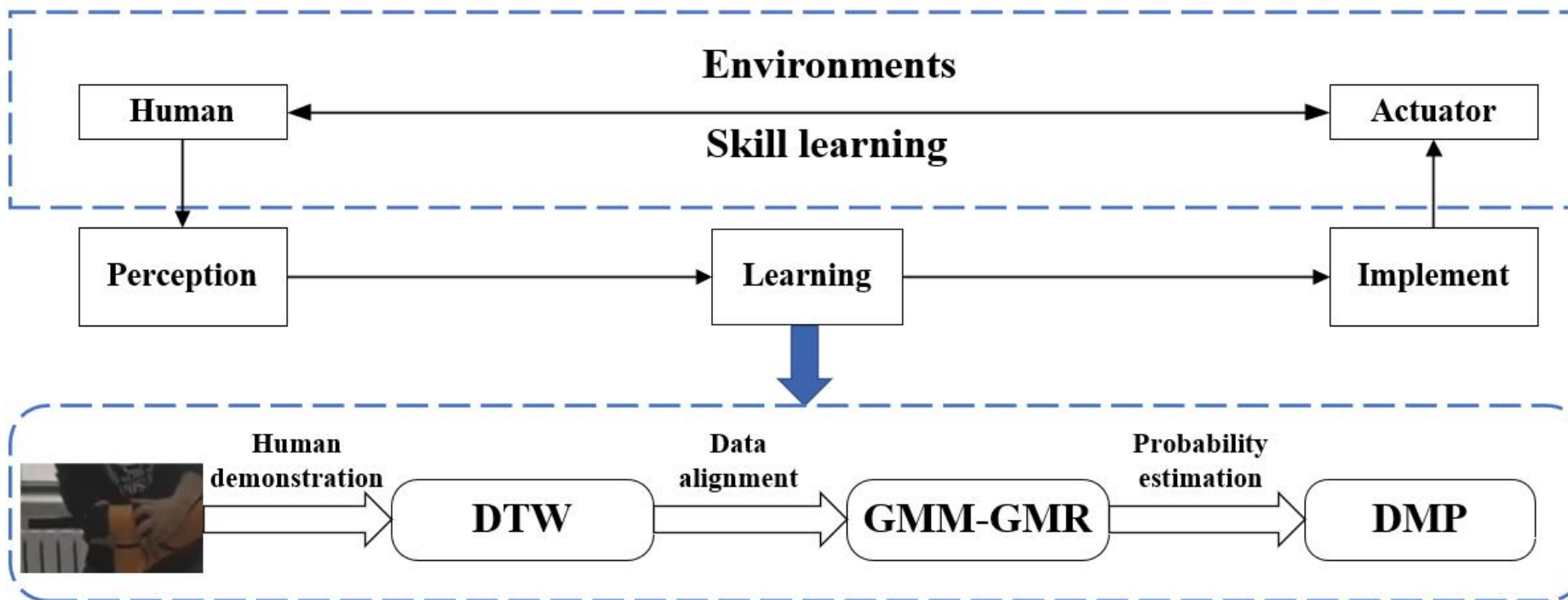
$$\mu_c = \begin{bmatrix} \mu_{s,c} \\ \mu_{\xi,c} \end{bmatrix}$$

$$\sum_c = \begin{bmatrix} \sum_{ss,c} & \sum_{s\xi,c} \\ \sum_{\xi s,c} & \sum_{\xi\xi,c} \end{bmatrix}$$





Overview



Task I: To accurately learn motor skills from human demonstrations and experiments data, data alignment is performed on the teaching data through Dynamic Time Warping (DTW).

Task II: Then, the data is analyzed using the statistical method Gaussian Mixture Model and Gaussian Mixture Regression (GMM-GMR). Ultimately, Dynamic Movement Primitives (DMPs) learn motor skills from human demonstrations and experiments data.



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Thanks for your listening!

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