

# Open Master Thesis Topic: Multisensory Exploration for Efficient Robot Reinforcement Learning



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## 1 Project Description

Humans rely on multiple sensory modalities like vision, touch, and proprioception, to explore and interact with their environment, especially in contact-rich tasks such as object manipulation. In contrast, most current robot learning systems still only rely on vision for exploration. This thesis aims to develop and analyze multisensory exploration strategies that leverage vision, force-torque sensing, tactile input, and proprioception to improve sample efficiency, representation learning objectives and task performance in reinforcement learning.

The research will be conducted in simulated contact-rich manipulation environments using IsaacLab. You will compare baseline methods such as Random Network Distillation (RND) with newly developed approaches that integrate multisensory information to guide exploration. A central goal is to characterize how different sensory modalities influence the agent's data collection, behavior and downstream task performance. Outstanding Work will be submitted to a conference with a potential publication.

### How to explore using all my senses?



**Related Work:** RND [1], Disagreement [2], ICM [3], Haptic based Curiosity [4], Sound Guides Representations and Explorations [5], See, Hear, Explore: Curiosity via Audio-Visual Association [6], Mimex [7], Exploration in deep RL survey [8].

## 2 Outline of Work Packages

**Note:** The following outline is intended solely to give an idea and will be adjusted depending on the project's progress and insights.

### WP 1

Duration: 1-2 month

The student has to refresh his/her knowledge in Deep Reinforcement Learning, focusing on Multimodal Learning and Exploration. First Baselines are getting implemented after getting to know the provided simulation environments in IsaacSim, which may be adjusted to the project's needs.

### WP 2

Duration: 3-4 months

The students build an experiment pipeline from data collection to data/model analysis, visualization, policy learning and evaluation. Next to Baselines, the student proposes and tests their own Exploration Strategies in close contact with the supervisors. All methods are being tested across multiple multisensory tasks.

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## WP 3

Duration: 2 months

Different exploration strategies are compared against each other, where their characteristics are visualized and the impact on performance is reported. Pipeline, Methods, and Results are documented and supported with appealing Visualizations. Outstanding Work will be submitted to a conference with a potential publication. Optional Real World Transfer is possible.

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## 3 Requirements

Enthusiasm, ambition, and a curious mind go a long way. There will be supervision provided to help the student understand basic and advanced concepts. However, experience in Reinforcement Learning, Robot Simulation and good (python) programming skills are needed to successfully work on this thesis. Prior knowledge of Curiosity/Exploration methods and Isaac Sim are a plus.

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## 4 How to Apply

Send an email to [rickmer.krohn@tu-darmstadt.de](mailto:rickmer.krohn@tu-darmstadt.de) with your CV and a short motivation email explaining your reason for applying for this thesis and your academic/career objectives.

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## References

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