



Lifelong Learning of Perception & Action in Autonomous Systems

Eric Eaton, PI (U.Penn), Satinder Baveja (U.Michigan), Michael Littman (Brown U.), Peter Stone (UT Austin), Fei Sha (USC)



Driving Applications: Lifelong Learning Machines (L2M)

DARPA Lifelong Learning Machines (L2M) Program



The L2M program seeks to develop substantially more capable learning systems that:

- Continuously improve performance with experience, and
- Rapidly adapt to new conditions and dynamic environments.

L2M studies both natural (biological) and artificial (machine learning) mechanisms for lifelong learning.

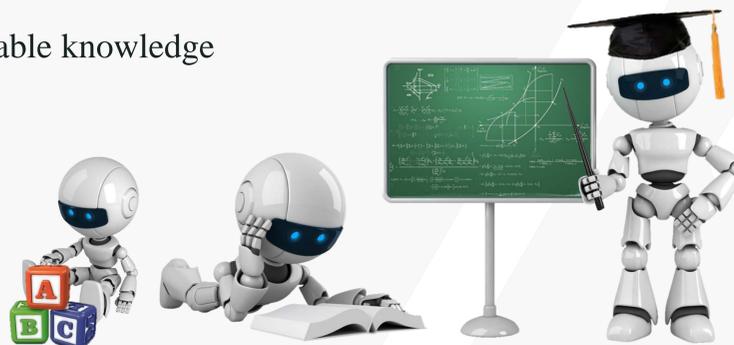
Our Research Goals

Develop a **comprehensive approach to lifelong machine learning in autonomous systems** that includes:

- A general-purpose continual learning framework that integrates classification, regression, and reinforcement learning
- Safe knowledge transfer between diverse tasks
- Scalable lifelong knowledge maintenance of structured, composable knowledge
- Self-directed learning for autonomous discovery
- Modeling the non-stationary distribution of tasks

Apply L2M to **autonomous mobile service robots**

- Focus on integrated perception and action
- Real and simulated unstructured, dynamic environments
- Persistent deployment of service robots across our universities



Application to Autonomous Mobile Service Robots

Service robotics provides a challenging and compelling application for L2M:

- They are expected to be versatile, capable of reliably performing a wide variety of tasks in diverse environments
- To be effective, they must be able to:
 - Rapidly learn new skills from minimal training
 - Operate effectively and safely alongside humans
 - Generalize effectively across diverse scenarios



SOTA: Current service robots are highly brittle – they only perform few predesigned and well-scripted tasks, without the capability to autonomously learn new tasks or adapt to anything but the smallest changes in their environment or goals.

Expected Outcome: L2M methods will be applied to control real and simulated service robots that are continually deployed in unstructured indoor office/university environments.

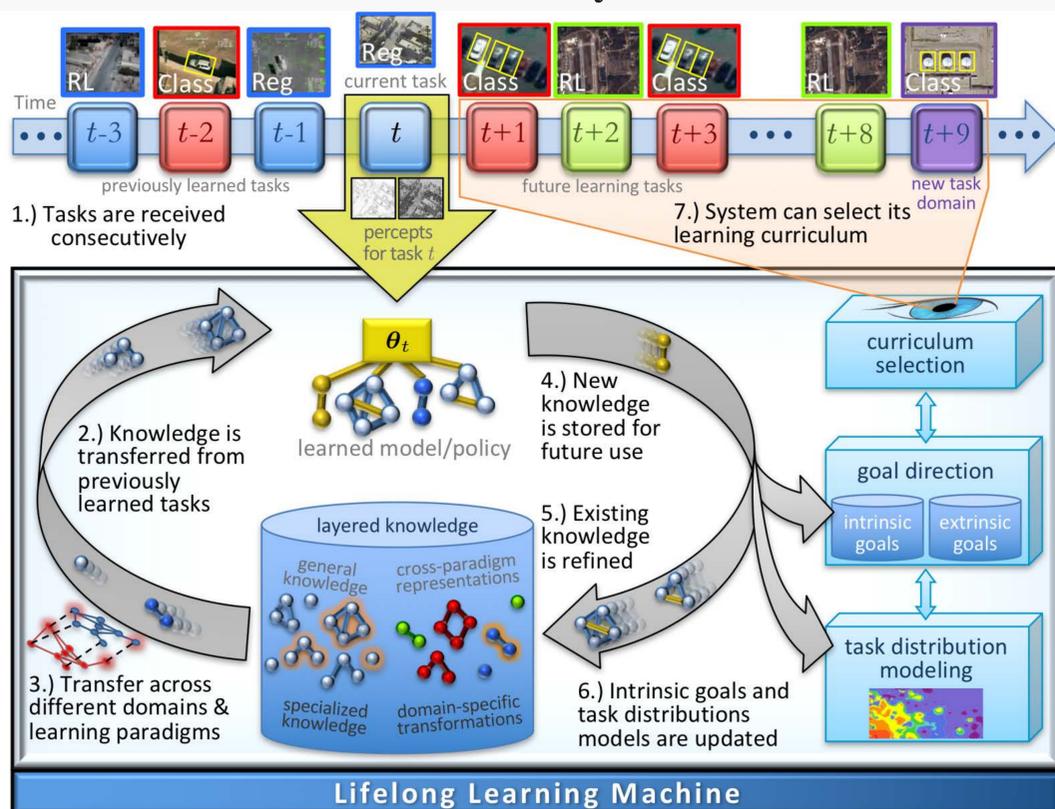
- Will support lifelong transfer across tasks/environments, enabling robots to learn new tasks and adapt dynamically
- Robots will be continually deployed across our universities

Evaluation via a Scavenger Hunt:

- Integrated evaluation scenarios that contain types of tasks all service robots will be expected to perform
- Numerous opportunities for sharing knowledge and task structures at multiple granularities
- Designed to be replayed by other researchers using other L2M approaches in different environments, enabling comparison



Summary of Our General L2M Framework



Key Innovations:

- Continual lifelong machine learning for perception and action
- Autonomous cross-domain transfer between diverse tasks and across different learning settings (e.g., classification, regression, & RL)
- Dynamic composition of layered knowledge
- Rapid learning from high-level task descriptions
- Selective attention mechanisms learn what knowledge to retain/forget
- Intrinsic motivation, safe exploration, and learning curricula drive the development of broad competence
- Adapt as non-stationary tasks/requirements change over time

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