Title: Action model learning

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Supervised learning

Unsupervised learning

Semi-supervised learning

Self-supervised learning

Reinforcement learning

Meta-learning

Online learning

Batch learning

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Rule-based learning

Neuro-symbolic AI

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Feature learning

Learning to rank

Grammar induction

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Multimodal learning

Apprenticeship learning

Decision trees

Ensembles Bagging Boosting Random forest

Bagging

Boosting

Random forest

k -NN

Linear regression

Naive Bayes

Artificial neural networks

Logistic regression

Perceptron

Relevance vector machine (RVM)

Support vector machine (SVM)

BIRCH

CURE

Hierarchical

k -means

Fuzzy

Expectation–maximization (EM)

DBSCAN

OPTICS

Mean shift

Factor analysis

CCA

ICA

LDA

NMF

PCA

PGD

t-SNE

SDL

Graphical models Bayes net Conditional random field Hidden Markov

Bayes net

Conditional random field

Hidden Markov

RANSAC

k -NN

Local outlier factor

Isolation forest

Autoencoder

Deep learning

Feedforward neural network

Recurrent neural network LSTM GRU ESN reservoir computing

LSTM

GRU

ESN

reservoir computing

Boltzmann machine Restricted

Restricted

GAN

Diffusion model

SOM

Convolutional neural network U-Net LeNet AlexNet DeepDream

U-Net

LeNet

AlexNet

DeepDream

Neural field Neural radiance field Physics-informed neural networks

Neural radiance field

Physics-informed neural networks

Transformer Vision

Vision

Mamba

Spiking neural network

Memtransistor

Electrochemical RAM (ECRAM)

Q-learning

Policy gradient

SARSA

Temporal difference (TD)

Multi-agent Self-play

Self-play

Active learning

Crowdsourcing

Human-in-the-loop

Mechanistic interpretability

RLHF

Coefficient of determination

Confusion matrix

Learning curve

ROC curve

Kernel machines

Bias–variance tradeoff

Computational learning theory

Empirical risk minimization

Occam learning

PAC learning

Statistical learning

VC theory

Topological deep learning

AAAI

ECML PKDD

NeurIPS

ICML

ICLR

IJCAI

ML

JMLR

Glossary of artificial intelligence

List of datasets for machine-learning research List of datasets in computer vision and image processing

List of datasets in computer vision and image processing

Outline of machine learning

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Action model learning (sometimes abbreviated action learning) is an area of machine learning concerned with the creation and modification of a software agent 's knowledge about the effects and preconditions of the actions that can be executed within its environment . This knowledge is usually represented in a logic-based action description language and used as input for automated planners .

Learning action models is important when goals change. When an agent acted for a while, it can use its accumulated knowledge about actions in the domain to make better decisions. Thus, learning action models differs from reinforcement learning . It enables reasoning about actions instead of expensive trials in the world. Action model learning is a form of inductive reasoning , where new knowledge is generated based on the agent's observations .

The usual motivation for action model learning is the fact that manual specification of action models for planners is often a difficult, time consuming, and error-prone task (especially in complex environments).

Action models

Given a training set E {\displaystyle E} consisting of examples e = (s , a , s ′) {\displaystyle e=(s,a,s')} , where s , s ′ {\displaystyle s,s'} are observations of a world state from two consecutive time steps t , t ′ {\displaystyle t,t'} and a {\displaystyle a} is an action instance observed in time step t {\displaystyle t} , the goal of action model learning in general is to construct an action model ■ D , P ■ {\displaystyle \langle D,P\rangle } , where D {\displaystyle D} is a description of domain dynamics in action description formalism like STRIPS , ADL or PDDL and P {\displaystyle P} is a probability function defined over the elements of D {\displaystyle D} . However, many state of the art action learning methods assume determinism and do not induce P {\displaystyle P} . In addition to determinism, individual methods differ in how they deal with other attributes of domain (e.g. partial observability or sensoric noise).

Action learning methods

State of the art

Recent action learning methods take various approaches and employ a wide variety of tools from different areas of artificial intelligence and computational logic . As an example of a method based on propositional logic, we can mention SLAF (Simultaneous Learning and Filtering) algorithm, which uses agent's observations to construct a long propositional formula over time and subsequently interprets it using a satisfiability (SAT) solver . Another technique, in which learning is converted into a satisfiability problem (weighted MAX-SAT in this case) and SAT solvers are used, is implemented in ARMS (Action-Relation Modeling System). Two mutually similar, fully declarative approaches to action learning were based on logic programming paradigm Answer Set Programming (ASP) and its extension, Reactive ASP. In another example, bottom-up inductive logic programming approach was employed. Several different solutions are not directly logic-based. For example, the action model learning using a perceptron algorithm or the multi level greedy search over the space of

possible action models. In the older paper from 1992, the action model learning was studied as an extension of reinforcement learning .

Nonetheless, further algorithms can be found that operate under different assumptions: FAMA can work even when some observations are missing, and it produces a general (lifted) planning model. It treats learning an action model like a planning problem, making sure the learned model matches the observations given.

NOLAM can learn general action models even from noisy or imperfect data.

LOCM focuses only on the order of actions in the data, ignoring any details about the states between those actions.

The family of safe action model (SAM) learning methods create models that guarantee any plans made with them will actually work in the real world. There’s also an extension called N-SAM that can learn action models with numeric conditions and effects.

Additionally, numeric action models like N-SAM can be used to improve reinforcement learning (RL) performance through the RAMP algorithm.

Literature

Most action learning research papers are published in journals and conferences focused on artificial intelligence in general (e.g. Journal of Artificial Intelligence Research (JAIR), Artificial Intelligence, Applied Artificial Intelligence (AAI) or AAAI conferences). Despite mutual relevance of the topics, action model learning is usually not addressed in planning conferences like the International Conference on Automated Planning and Scheduling (ICAPS).

See also

Machine learning

Automated planning and scheduling

Action language

PDDL

Architecture description language

Inductive reasoning

Computational logic

Knowledge representation

References