Toward Dreaming Robots

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Why animals and humans dream is still a controversial question in brain science. Psycho-physical experiments with humans have shown an improved performance after REM sleep which is connected to dreaming. Thus, although dreaming mostly is mentioned in context of memory consolidation it is outright evident that it influences the ability of solving tasks. Therefore, it seems to be an interesting aspect with respect to AI. As a consequence it seems interesting to find a way to implement a functional model of "dreaming". Doing so one has to connect presumed functional aspects of a dream to organic parts of the brain and model them by using their counterparts in robot control and planning. The simplest approach to dreaming is to design a biological inspired autoregressive model, which is the consecutive application of forward prediction in a loop like fashion. Here we propose a dream mechanism which is able to conduct basic aspects of dreaming and also identify regions of the human brain where the parts of the model may be located.

Dreams consist of successions of images, ideas, emotions, and sensations occurring involuntarily in the mind during certain stages of sleep, especially during REM sleep and is independent from the stimulus outside environment[2]. The two important organic parts of the brain for dreaming are *Occipital lobe* and *Thalamus*. The function of the *Occipital lobe* is that it contains the primary visual cortex and is the part of the brain where dreams come from. The *Thalamus* is also named "gatekeeper": It appears to serve as a gate for sensory information that is open during wakefulness and shut off during sleep. The visual information received from retina of the eye will send to *lateral geniculate nucleus* (LGN) inside the Thalamus and in turn projects to the primary visual. In addition, *Thalamic nuclei* have strong reciprocal connections with the cerebral cortex, forming *thalamo-cortico-thalamic* circuits that are believed to be involved with consciousness and play an important role on dreaming. Thus, we assume that the function of *thalamo-cortico-thalamic* circuits is used to process some kind of progressive self-prediction. We intent to use a nonlinear system to predict the environment, which we like to design in a similar was as *thalamo-cortico-thalamic* circuits.

The dream mechanism consists of classic machine learner and meta machine learner. The main task of the classic machine learner is that it will predict next step of the input as autoregressive model. We apply Echo State Networks (ESN) for the classic machine learner. ESN is a simple type of a reservoir computer and have good capacity for predict a nonlinear system with the capacity of the short term memory[1]. However if the training data is not enough for ESN, it will cause to the inaccurate prediction. In order to improve the accurate prediction of ESN, we add meta machine learner to the dream mechanism. The task of the meta machine learner is to predict the next error of the prediction produced from the classic machine learner. In this case we could reduce the error of the classic machine learner with limited training cycle. We apply the concept of the decision tree to achieve the ability of meta machine learner. For the dream mechanism, it will conduct two steps *awake state* and *dreaming state*. In the *awake state*, the robot could collect the training patterns which could be predictable from the mechanism of Intelligent Adaptive Curiosity[3] and train the classic machine learner with training patterns. In the *dreaming state*, we will turn off the sensory input and the robot will self-predict the transition of the behavior based on the dream mechanism. It means that the robot will not receive any information from outside environment and make the behavior decision autonomously. In the dream mechanism, the robot can imagine the variation of the states based on the experiences and learn from these states in a biologically inspired fashion. It is also intended how useful to create a stochastic representation of the environment.

References

[1] H. Jaeger. The" echo state" approach to analysing and training recurrent neural networks-with an erratum note'. Technical report, Technical Report GMD Report 148, German National Research Center for Information Technology, 2001.

[2] M. Jouvet. *The paradox of sleep: The story of dreaming*. MIT Press (MA), 2001.

[3] Pierre-Yves Oudeyer. Intelligent adaptive curiosity: a source of self-development. 2004.