Real-time Robot Teaching Dialog

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1 Introduction

Recent trends in machine learning, especially the transfer learning (Tan (2018)) and the big-data model pretraining principles, have been reaching impressive results in many tasks that are generally being defined by a pre-collected dataset. The common routine is to 1/ collect a large amount of data samples; 2/ train or fine-tune a neural model on a majority part of it; 3/ evaluate the model on the rest. The trained model is hereby heavily dependent on samples collected in advance and strictly limited to learn only on the data fetched beforehand. When speaking of the training time and computing power requirements, these models are habitually pretrained offline and hardly can be retrained in real-time applications.

This work presents a method for learning new data gathered ”on-the-run” by an iterative retraining of a neural network in real-time. At the beginning of the process, there are no data samples available and the model is being optimized by an iterative voice interaction with a human. At every time-step, the human arbitrarily decides about the feedback to the model's last move and hereby every single training session is unique and completely independent of any pre-collected data. The principle follows the action-state-reward recipe known from reinforcement learning, however, instead of maximizing the cumulative reward by exploring a huge amount of state-action combinations, the neural network here is fully retrained right after gaining new experience – a human feedback to the last state-action combination. The simplicity of the network architecture together with today's computing power enable to run the method, including the model retraining, in real-time.

The real-time model retraining method is embedded into a sophisticated framework (illustrated in Fig. 1) that enables the deployment on real devices - robots. The method is general and applicable to a target robot of any type, defined by its possible moves – skills to be learned.

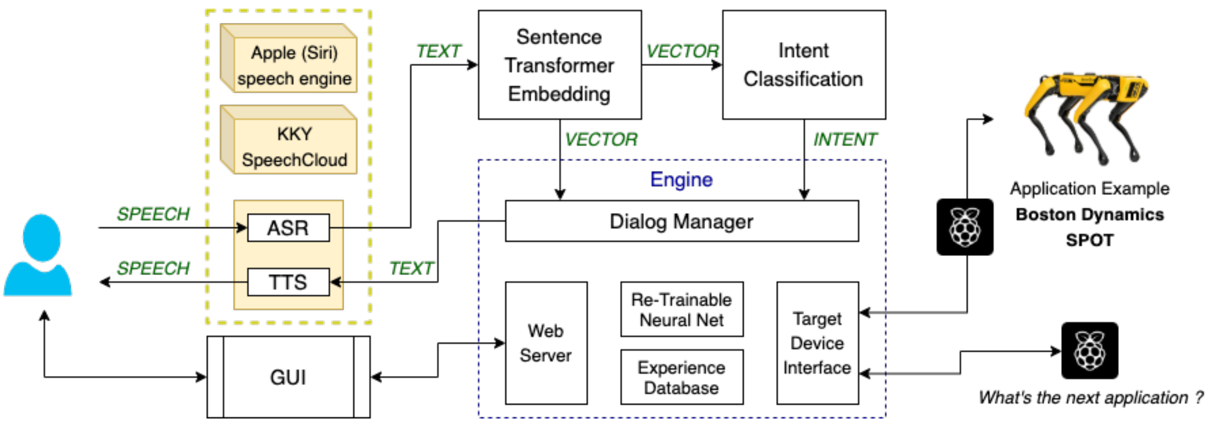

Figure 1: Overall diagram of the real-time robot teaching procedure.

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2 Voice Interaction and Dialog

The framework is equipped with a speech module that enables a voice interaction with a human during the real-time training. Two separate methods have been involved in parallel to handle the speech processing part: 1/ the speech engine by Apple (even in the Czech language); 2/ the SpeechCloud platform (Švec (2016)), which has recently been updated to SotA technologies including Wav2Vec ASR and VAD – voice activity detection by Google. The virtually lossless ASR is the key for further understanding. The ASR result is turned into a numerical embedding of a fixed length by the Sentence-transformer (Lehečka (2021)), which is based on a large Czech corpus. Using this text embedding technique is crucial for semantic generalization of training samples,. The model is then able to react correctly even to never heard phrases if it already knows similar phrases of the same meaning.

Furthermore, a simple neural classifier was implemented to determine the intent of the input sentence and to help the manager control the dialog. There are 4 possible intents the classifier selects from: 1/ *Stop* – to initial state; 2/ *Yes* – confirmation; 3/ *No* – correction; 4/ *Command* – one of the pre-defined robot moves. New data samples (robot experience) are being saved for future retraining.

Finally, the dialog manager is connected to a *Tornado* server, which enables the communaction with a *React*-based web interface for dialog visualization and further interaction.

3 Application

The presented learning method as well as the overall framework is general and can be used to teach any target device. Fig. 2 shows three examples of a successful application.

(a) *Boston Dynamics Spot*. Motion learning. (BD (2022))

(b) *CamBot*. Object recognition learning.

(c) *AimtecBot*. Motion learning (touch feedback).

Figure 2: Examples of successfully connected target devices.

Acknowledgement

I would like to express my gratitude to Alza.cz a. s. for lending the Boston Dynamics Spot. Next, I would like to thank Aimtec a.s. for a valuable cooperation on this project.

References

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