

Case Study (Robot in household chores)

Syntax Analysis

Divya Kundra and Ashish Sureka, *An Experience Report on Teaching Compiler Design Concepts using Case-Based and Project-Based Learning Approaches*, International Conference on Technology for Education (T4E 2016)

GOLEMS is Humanoid Robotics Lab at Georgia Institute of Technology. The lab works towards developing robots having human and even super human capabilities. The current task of GOLEMS lab is to build a robotic system that picks and drops things from one room to another. The developers at GOLEMS lab have found a new way to represent and verify the controlling mechanisms of robots using Context Free Grammars. The production rules of the grammar represent a task decomposition of robot behavior. The name that they have given to the grammars controlling robots is Motion Grammar. The motion grammar describes the language of the robotic system. The terminal symbols of the language are robot events and predicates. They plan to model the behavior of the robot in uncertain environments with this grammar. Context-free grammars can model robot behavior, providing advantages in hierarchical task decomposition, verification, and supervisory control. The lab has several reasons to use context free grammar over regular language. The developers at the lab have found out that they we can describe a broader class of system behavior using the Context-Free language class than with regular languages. The Context-Free set provides more descriptive power while maintaining the efficiency and verifiability of regular languages. Additionally Context-Free Grammars provide a natural representation for hierarchies in the system. For example to build the grammar for a robot that does loading and unloading task is as shown below in Fig.1. The associated parse tree is also shown. In production (1), the system will repeatedly perform [load] operations until receiving a [full] token from production (2). Then the system will perform [unload] operations of the same number as the prior [load] operations. This simple use of memory is possible with Context- Free systems.

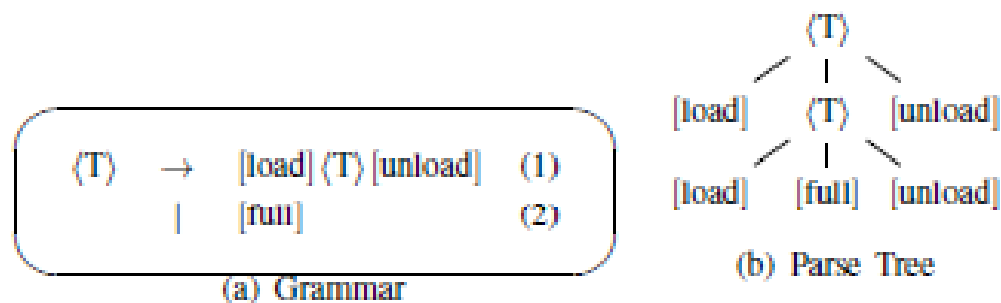


Fig. 1 : CFG and parse tree for loading and unloading task

To directly use the grammar for robot control, it must be translated to machine code, i.e, a computer program; which is the parser generation. Since the model is of a Context free grammar, the developers should decide on the terminal symbols. The productions of the grammar form top-down task decomposition, defining an online control policy for the robot. During operation, selected productions will execute the semantic rules associated with productions to compute input commands for the robot. Thus, controlling the robot will correspond to parsing sensor readings online according to the rules of the grammar. The critical difference between program translation and online control of the robot is time. In program translation, tokens come from a static file available a priori. In robot control, tokens come from sensor readings in real-time. While a compiler need only give its output at the end of the file or statement, a robot must continually respond to its environment.

The precise requirement of the system is that first the robot needs to understand the demographics of the area in which it will be operating. For this a map grammar is required which converts the graph of the area into a map. Then the action grammar is designed using Motion Grammar to model the robotic system operating within mapped environment. The robot is to be used in a home where the rooms are - bedroom, kitchen, living room, garage bathroom and a hall. The hall is connected directly to bedroom, living room, garage and bathroom whereas the kitchen is connected directly to living room. Then to merge the robot with the environment, Motion Grammar is applied. The action grammar has map symbols with each map symbol maintaining only the transitions allowed by the map. For instance one of the task of robot's include collecting soda from kitchen and bringing to bedroom. The robot would start from the hall and navigate its way to the kitchen. From the kitchen it would pick up task of picking up the bottle and navigating back its way to bedroom. Once it reaches to bedroom it would stop, place the object and go back to the hall. Thus identify the challenges that needs to be taken care of while designing the Motion Grammar. Suggest suitable Motion Grammar for the required system.