Conversion and Parsing of Tree Transducers for Syntactic Pattern Analysis

Wei-Chung Lin and King-Sun Fu

Received June 1982; revised January 1983

The conversion algorithms for two classes of tree transducers, i.e., simple generalized syntax-directed tree translation (SGSDTT) and generalized finite state transformation (GFST), are proposed. A top-down backtrack parsing algorithm for a GFST is presented. The minimum distance structure-preserved error-correcting tree automaton is also extended to be a parser for SGSDTT. Finally, the tree transducers are applied to modeling and analysis of human motion.

KEY WORDS: Syntactic pattern recognition; tree; top-down tree transducer; bottom-up tree transducer; generalized syntax-directed translation; generalized syntax-directed tree translation; generalized finite-state transformation; tree grammar; top-down backtrack parsing; minimum-distance structure-preserved error-correcting parser; human motion modeling; grammatical inference; motion analysis.

1. INTRODUCTION

The application of language translation theory to syntactic pattern recognition has received increasing attention during the past few years. Thomason and Gonzalez (1,2) applied the syntax-directed translation schema (SDTS) to the recognition of noisy patterns. The SDTS was used to transform an unacceptable input into a recognizable string. You and Fu (16) applied an attributed finite transducer for boundary smoothing of an object in an image. Tai and Fu (17) proposed a semantic syntax-directed translation scheme for the transformation from a set of pure patterns to a set of noisy and distorted patterns. Shi and Fu (18) applied a syntax-directed translation to...
mapping one (attributed) expansive graph language to another. Fan and Fu (3-5) used the concept of translation as a mechanism to characterize the dynamic process of image sequence. A generalized syntax-directed tree translation model was proposed to analyze a sequence of images of a traffic intersection scene.

In the literature of formal languages, several models of syntax-directed translation have been proposed (6-9) to describe the generation of machine code from parse trees during the process of compilation of a computer program. Another development has been the study of automata called "tree transducers" which map trees into trees (10-14). Among all the tree transducers, the top-down and bottom-up tree transducers are the earliest ones proposed. A top-down tree transducer (TDTT) reads input trees by beginning at the root and working toward the leaves while a bottom-up tree transducers (BUTT) reads input trees from the leaves and working toward the root.

In general, the desired capabilities of a tree transducer include the following: (1) Copying an output tree after nondeterministic processing of the input tree. (2) Deciding whether or not to delete a tree after processing it. (3) Copying an input tree and processing the copies differently. Both TDTT and BUTT fail to have certain above mentioned capabilities. A TDTT does not have the capabilities (1) and (2) while a BUTT does not have the capability (3). Hence, there exists translations which can be implemented by a TDTT, but not by a BUTT. There also exist translations which can be implemented by a BUTT, but not by a TDTT.

In order to overcome the deficiencies of TDTT and BUTT, two generalized tree transducers have been proposed. Engelfriet (14) presented a generalized finite-state transformation (GFST) which can be conceived as a TDTT together with the capabilities of placing a copy of a processed input subtree in the output tree and of deleting a processed subtree. Fan and Fu (5) proposed a generalized syntax-directed tree translation (GSDTT) based on the definition of generalized syntax-directed translation (GSDT) given by Aho and Ullman (9) and showed that both TDTT and BUTT are special cases of GSDTT.

Although the two approaches are developed from different points of views and have quite different operations for translation, there exists a close relationship between them. In this paper, we propose two conversion algorithms for the transformation between a GFST and a simple GSDTT (SGSDTT) which is a subclass of GSDTT. A top-down backtracking parsing algorithm for GFST is presented. A natural extension of minimum distance structure-preserved error-correcting tree automaton to a parser for SGSDTT is also described. Finally, we apply the tree transducers to human motion modeling and analysis.