Zoltán Fülöp
Department of Computer Science
József Attila University
Szeged, Hungary

Heiko Vogler
Department of Computer Science
Dresden Technical University
Dresden, Germany

Syntax-Directed Semantics

Formal Models Based on Tree Transducers

July 16, 1998

Springer-Verlag
Berlin Heidelberg New York
London Paris Tokyo
Hong Kong Barcelona
Budapest

Dedicated to Joost Engelfriet and Ferenc Gécseg.

Preface

The subject of this book is the investigation of tree transducers. Tree transducers were introduced in theoretical computer science in order to study the general properties of formal models which give semantics to context-free languages in a syntax-directed way. Such formal models include attribute grammars with synthesized attributes only, denotational semantics, and attribute grammars (with synthesized and inherited attributes). However, these formal models share certain constituents which are irrelevant in the investigation of the general properties considered in this book. In particular, we can abstract (a) from derivation trees of the context-free grammar and take trees over some ranked alphabet, (b) from the semantic domain of the model and use the initial term algebra instead, and finally (c) from the machine-oriented computation paradigm, which maintains the incarnation information of recursive function calls, and take a term rewriting semantics instead. Applying these three abstraction steps to attribute grammars with synthesized attributes only, to denotational semantics, and to attribute grammars we obtain the concepts of *top-down tree transducer*, *macro tree transducer*, and *attributed tree transducer*, respectively. The *macro attributed tree transducer* combines the concepts of the macro tree transducer and the attributed tree transducer. This book explores the general properties of these four types of tree transducers.

The general properties which we examine are the transformational power of the tree transducers above, the restriction of their resources, and an intensive investigation into the composition and decomposition of the tree transformations induced by them. Our aim is to develop a theory of the these types of tree transducers and thereby contribute to theoretical computer science.

We intended this book for those who work in an academic environment, e.g., in universities or research institutes, and who deal with theoretical computer science. It is a small handbook of recent results on tree transducers that can be used both for carrying out further research and giving lectures in the topic. The subject can also be taught to graduate students in computer science. However, as prerequisites, some basic knowledge of universal algebra and of automata and formal language theory is necessary to use the book effectively.

The background to the book is as follows. We began to carry out research into the theory of tree transducers independently from each other many years ago. Since meeting for the first time in 1986 in Szeged, Hungary, we have continued a constant discussion about the state of the art. We have attempted to systematize the results from different research schools using a unified terminology. Some years ago we decided to write down our knowledge in the form of a book and the result is in your hands.

The authors are grateful to many colleagues who in one way or another contributed to this book. The first author was introduced to the subject by Ferenc Gécseg and benefited much from valuable discussions with Zoltán Ésik, Sándor Vágvölgyi, and Magnus Steinby. The second author had the luck to meet Joost and Louco Engelfriet and, also, to learn the theory of tree transducers from Joost. He had fruitful discussions about the subject with Armin Kühnemann and Thomas Noll. Both authors are very grateful to Armin Kühnemann for careful reading of the manuscript. They would also like to thank Sven Buchholz, Matthias Gette, and Christian Lescher for taking over the troublesome task of drawing the figures. Many thanks are also due to the computer system managers Károly Dévényi and Sebastian Maneth who maintained the intensive computer connection between our universities on which our joint progress was based.

Last but not least, the authors are indebted to Springer-Verlag, especially to Dr. Hans Wössner and his team, for the pleasant and highly professional cooperation during the preparation of the camera ready version of this monograph.

Our work was supported by different grants. We received much assistance from the German-Hungarian Research Project "Formal Languages, Automata and Petri-Nets" (1995-1997) supported by the *Te'T Foundation, Budapest, Hungary*, grant no. D/102 (formerly: No. OMFB-NPI-102) and by the *Forschungszentrum Karlsruhe, Germany*, grant no. 233.6, respectively. We were also supported by the Hungarian Scientific Foundation (OTKA), grant no. T 015843 and by the Ministry of Culture and Education of Hungary, grant no. FKFP 0095/1997.

May 1998

Zoltán Fülöp
Szeged, Hungary

Heiko Vogler
Dresden, Germany

Contents